1975

SOIL PLANT NUTRIENT RESEARCH REPORT

compiled by

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Department of Soil Science
University of Saskatchewan
Saskatoon, Saskatchewan

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This report summarizes the field research investigations on soil fertility carried out during the 1975 season by the staff of the Department of Soil Science, University of Saskatchewan, Saskatoon. These investigations were supported by research funds provided from the following sources: The Saskatchewan Department of Agriculture; Canada Department of Agriculture; Western Co-operative Fertilizers Limited; Monsanto Limited, and Imperial Oil.

In soil fertility research, it is vital to conduct experiments under a wide variety of soil and climatic conditions. Almost all of the investigations were carried out on individual farms throughout the province. Without the generous co-operation of the many farmers involved, it would be impossible to conduct research of this type. A sincere thank-you is extended to all farmers who put up with considerable inconvenience to accommodate these experiments.

The project in the irrigation area is a co-operative project between the Department of Soil Science and the Conservation and Development Branch of the Saskatchewan Department of Agriculture. Glenn Annand and Brad Korbo were summer assistants with the project and took care of all moisture readings, water application and plot maintenance.

All field operations associated with the placement of field plots including seeding, routine maintenance and harvest were carried out by summer assistants including Paul Kneeshaw, Brad Choquette, Judy Dyck and Peggy Bauer. Nitrogen, protein and oil analyses of plant material as well as all routine soil analyses were performed by the Soil Testing Laboratory. Mass Spectrometric analyses were performed by Mervin Manthey with assistance from Lloyd Johns.

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INTRODUCTION

In 1971 a research project was initiated in the Outlook area of the South Saskatchewan River Irrigation Project with the following objectives:

1) To assess effects of nutrient levels, particularly of nitrogen, and irrigation scheduling on the yields and quality of a variety of crops including barley, soft wheat, rapeseed and alfalfa.

2) To provide guidelines on the fertilizer and water requirements for optimum production of these crops under irrigation.

3) To establish guidelines for target yield estimations.

The work from previous years in this project has been reported in the 1971 to 1974 Soil Plant Nutrient Research reports.

The alfalfa work during 1971 to 1973 showed a consistent lack of response to fertilizer phosphorus irrespective of soil test level. In 1974 attempts were made to establish plots in which phosphorus was applied and incorporated prior to planting. These experiments both failed and had to be abandoned. Therefore, in 1975 a sampling survey of alfalfa fields was conducted to gain further information on relationships between soil and plant analysis. This work is presented in a subsequent section.

1.1 Nutrient and water requirements of barley, soft wheat and rapeseed.

EXPERIMENTAL METHODS

Two major experiments were conducted with barley, soft wheat and rapeseed; one on an Elstow loam soil (Pederson farm) and the other on a Bradwell very fine sandy loam soil (Cameron farm). Both experimental plot areas were within the same fields and on the same soil types as the experiments conducted in 1974.

A major departure in plot selection was that the area on the Elstow soil had been fallowed in 1974. This was selected with the expressed purpose of obtaining a field that was high in nitrogen to allow further study of nitrogen response on soil with this level of nitrate nitrogen.

Soil analysis from samples taken at seeding time indicates very high nitrogen levels on the Elstow soils and medium nitrogen levels on the Bradwell soils (Table 1.1.1). Phosphorus levels were very low at both sites and potassium levels were very high.

The cultivars used were Bonanza barley, Springfield soft wheat and Midas rapeseed. These plots were rototilled prior to seeding. Seeding was done with a double-disc press drill with seven rows per plot and a seven-inch row spacing. Plot length was 15 feet. Seeding was done on May 5th for the Bradwell soils and May 6th for the Elstow soils.

Phosphate applications with the seed were made to all plots at a rate of 40 lbs P_2O_5/acre with barley and soft wheat and 30 lbs P_2O_5/acre with rapeseed. Monoammonium phosphate (11-55-0) was used as the phosphate source throughout. The fertility treatments included a range of nitrogen rates from 0 to 200 lbs N/acre (Table 1.1.2). All nitrogen was applied as a surface broadcast application of ammonium nitrate (34-0-0) applied at the time of seeding.

Avadex was used as a preplant application on barley and Treflan was applied preplant on rapeseed. Post-emergent herbicides included TOK-RM for rapeseed, Buctril-M for wheat and barley and in addition on the Bradwell soil TCA was applied to barley.

Infestations of flea beetles on the rapeseed necessitated two sprayings with malathion.

Table 1.1.1. Spring soil analyses for irrigation experiments.

Depth (Inches)	NO_3-N	P lbs/acre	K	pH	Cond. mmho/cm
		ELSTOW: loam (Pederson site) BARLEY			
0-6	29	10	460	7.1	0.4
6-12	15	2	155	7.5	0.3
12-24	20(64)*	2	330	7.9	0.3
24-36	18	2	360	8.4	0.3
36-48	16	2	500	8.5	0.6
		SOFT WHEAT			
0-6	31	8	480	6.9	0.3
6-12	18	2	180	7.4	0.3
12-24	20(69)	2	360	7.9	0.3
24-36	14	1	400	8.4	0.3
36-48	24	1	730	8.1	2.4
		RAPESEED			
0-6	36	10	560	7.1	0.4
6-12	18	2	175	7.5	0.3
12-24	20(74)	2	340	7.9	0.3
24-36	14	2	370	8.3	0.3
36-48	24	2	530	8.6	0.4
		BRADWELL: very fine sandy loam (Cameron site) BARLEY			
0-6	11	9	845	7.6	0.3
6-12	10	1	220	7.8	0.3
12-24	14(35)	2	390	8.2	0.3
24-36	12	2	500	8.7	0.3
36-48	12	2	560	8.7	0.3
		SOFT WHEAT			
0-6	11	7	845	7.6	0.3
6-12	9	1	270	7.8	0.3
12-24	20(40)	1	310	8.1	0.3
24-36	12	1	410	8.6	0.3
36-48	14	4	540	8.6	0.3
		RAPESEED			
0-6	10	7	825	7.6	0.3
6-12	6	1	270	7.7	0.3
12-24	16(32)	1	440	8.1	0.3
24-36	10	1	330	8.5	0.3
36-48	12	2	400	8.8	0.4

* Numbers in brackets are NO_3-N totals to 24 inches.

Table 1.1.2. Fertility and water treatments used in irrigation experiments.

Fertility Treatment Number	Nitrogen Applied (lbs/acre)
1	0
2	50
3	75
4	100
5	150
6	200

Note: Barley and soft wheat also received 40 lb P_2O_5/acre. Rapeseed also received 30 lb P_2O_5/acre. All phosphate was seed placed.

Water Schedule	Treatment
Dryland	No irrigation
A	Missed first irrigation
B	Missed second irrigation
C	Missed third irrigation
D	Received all irrigations

Table 1.1.3 Depth of water required to replenish soil moisture in irrigation experiments.

Deep Tensiometer Reading	Depth of water in inches Elstow soil	Bradwell soil
0.3	2.5	2.0
0.3 - 0.7	3.5	
greater than 0.7	4.5	4.0

For the irrigation scheduling portion of these experiments five water schedules were utilized (Table 1.1.2). In water schedule A the first irrigation was deleted, in water schedule B the second irrigation was deleted, in water schedule C the third irrigation was deleted whereas water schedule D received all irrigations. The dryland treatment received no applications of irrigation water.

The acutal scheduling of irrigation was determined by tensiometers. Shallow tensiometers were installed at the 4 to 6 inch level initially and then moved down to the 6 to 9 inch level in late June. Deeper tensiometers were installed initially at the 10 to 12 inch depth and moved down to the 16 to 18 inch depth in late June. The shallow tensiometers were installed in fertility treatment three of all water treatments and in all four replicates. The deeper tensiometers were installed only in replicate three of fertility treatment three in all water treatments.

The tensiometers were utilized to determine both the timing of irrigation and the amount to apply. Irrigation water was applied when the shallow tensiometers indicated a soil moisture tension of 0.5 atm for both soils. The amount of water to apply was determined by the reading obtained on the deep tensiometers as indicated in Table 1.1.3 (page 4).

Neutron access tubes were installed to a depth of 4 feet in fertility treatment three of all replicates and all water treatments. Moisture monitoring was then conducted with the neutron probe except for the 0 to 6 inch depth which was done gravimetrically. Moisture measurements were made at the time of installation at seeding time, one day before and two days after each irrigation and again at harvest time.

Irrigation water was applied through the use of a custom designed sprinkler system which allowed separate timing and amounts of water to the various irrigation scheduling treatments under study. The timing and amounts of irrigation water applied are presented in Table 1.1.4.

At harvest, yield samples were taken from all treatments by clipping at the soil surface the three center rows of the seven-row plot over a length of ten feet. The samples were then dried, threshed and weighed. Subsamples of both grain and straw were taken, replicates of individual treatments from each plot were composited, mixed and ground. Analyses were performed for percent nitrogen content of the straw, percent protein content of the grain and in the case of rapeseed, percent oil content of the seed (unground).

RESULTS AND DISCUSSION

Response of Barley, Soft Wheat and Rapeseed to Nitrogen Fertilization

Data on the effect of nitrogen fertilization on the yield, protein content and nitrogen uptake of soft wheat, barley and rapeseed and oil content of rapeseed are presented in Tables 1.1.5 to 1.1.10. Graphical presentation of selected data is in Figures 1.1.1 to 1.1.3.

For the Bradwell soil where soil nitrogen levels were medium, strong responses to nitrogen were recorded for all crops. The response under the dryland treatment was much less than for all other irrigation schedules. Water treatments A and B had essentially the same nitrogen response pattern and this was much less than the nitrogen response under water treatments C and D. The largest response was recorded for barley in water treatment C where yields were increased from 37.1 bushels/acre to 101.8 bushels/acre.

Table 1.1.4. Amounts and timing of irrigation applications.

Crop and Water Schedule					Total Water (Irrig. + Rain) (inches)
			Elstow soil (Pederson)		
			Growing Season Rainfall 6.3"		
Barley					
A		July 4, 3.9"	July 14, 3.9"	July 25, 3.8"	17.9
B	June 14, 3.6"		July 14, 3.9"	July 25, 3.8"	17.6
C	June 14, 3.1"	July 3, 3.7"		July 26, 3.6"	16.7
D	June 15, 3.1"	July 3, 3.7"	July 18, 3.4"	July 26, 3.6"	20.1
Soft Wheat					
A		July 4, 3.9"	July 14, 3.9"	July 25, 3.8"	17.9
B	June 14, 4.0"		July 14, 3.9"	July 25, 3.8"	18.0
C	June 15, 3.1"	July 3, 3.7"		July 26, 3.6"	16.7
D	June 15, 3.1"	July 3, 3.7"	July 18, 3.4"	July 26, 3.6"	20.1
Rapeseed					
A		July 11, 3.3"	July 25, 3.6"		13.2
B	June 25, 3.4"		July 25, 3.6"		13.3
C	July 2, 2.9"	July 13, 3.3"			12.5
D	July 2, 2.9"	July 13, 3.3"	July 23, 3.8"		16.3
			Bradwell soil (Cameron)		
			Growing Season Rainfall 6.2"		
Barley					
A		July 20, 3.4"			9.6
B	July 4, 3.2"				9.4
C and D	July 5, 4.4"	July 18, 4.0			14.6
Soft Wheat					
A		July 20, 3.4"	July 31, 3.2"		12.8
B	July 4, 3.2"		July 31, 3.2"		12.6
C	July 5, 4.4"	July 18, 4.0"			14.6
D	July 5, 4.4"	July 18, 4.0"	July 31, 3.2"		17.8
Rapeseed					
A		July 20, 3.4"	July 31, 3.2"		12.8
B	July 4, 3.2"		July 31, 3.2"		12.6
C	July 5, 4.4"	July 18, 4.0"			14.6
D	July 5, 4.4"	July 18, 4.0"	July 31, 3.2"		17.8

Table 1.1.5. The effect of nitrogen fertilization and irrigation scheduling on the yield and nitrogen uptake of Bonanza barley grown on Bradwell soil (Cameron site).

N Applied lb/ac	Yield Grain bu/ac	Yield Straw lb/ac	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (lb/acre) Grain	Straw	Total
				DRYLAND				
0	35.6	1473	1.20	---	0.43	----	6.3	----
50	47.3	2686	0.86	9.6	0.40	34.9	10.7	45.6
75	38.4	2029	0.94	9.7	0.30	28.6	6.1	34.7
100	39.0	3084	0.62	12.4	0.80	37.1	24.7	61.8
150	45.5	3450	0.64	12.7	1.10	44.4	38.0	82.3
200	42.1	3298	0.63	13.4	1.25	43.3	41.2	84.6
				WATER A				
0	37.1	1460	1.22	8.3	0.35	23.7	5.1	28.8
50	62.3	2838	1.06	9.0	0.45	43.1	12.8	55.8
75	60.8	2794	1.05	----	0.45	----	12.6	----
100	71.3	3205	1.07	10.2	0.58	55.9	18.6	74.4
150	74.8	3367	1.07	10.4	0.75	59.8	25.3	85.0
200	74.8	3321	1.08	11.0	1.00	63.2	33.2	96.4
				WATER B				
0	34.2	1239	1.38	8.2	0.28	21.5	3.5	25.0
50	64.9	2839	1.10	7.8	0.33	38.9	9.4	48.3
75	55.4	2339	1.14	8.8	0.33	37.4	7.7	45.2
100	78.6	3513	1.07	11.0	0.40	66.4	14.1	80.5
150	77.5	4393	0.86	12.2	0.85	72.6	37.3	110.0
200	78.1	4246	0.88	13.2	0.95	79.2	40.3	119.5
				WATER C				
0	37.1	1478	1.20	8.0	0.38	22.8	5.6	28.4
50	62.0	2768	1.08	8.7	0.35	41.4	9.7	51.1
75	73.4	3350	1.05	8.4	0.33	47.4	11.1	58.4
100	84.8	3643	1.12	9.1	0.38	59.3	13.8	73.1
150	98.1	3829	1.24	11.0	0.65	82.9	24.9	107.8
200	101.8	4149	1.18	11.3	0.98	88.4	40.7	129.0
				WATER D				
0	38.3	1560	1.18	7.7	0.33	22.7	5.2	27.8
50	57.9	2853	0.99	8.3	0.40	36.9	11.4	48.3
75	75.9	3628	1.01	8.5	0.30	49.6	10.9	60.4
100	84.7	3821	1.09	10.0	0.45	65.1	17.2	82.3
150	97.0	4351	1.08	10.2	0.55	76.0	23.9	99.9
200	95.4	4650	1.00	12.1	1.05	88.7	48.8	137.5
LSD (.05)	11.4	665	0.17					

[1]Grain protein based on % N at 13.5% moisture X 6.25; straw % N is on oven dry basis.

Table 1.1.6. The effect of nitrogen fertilization and irrigation scheduling on the yield and nitrogen uptake of Bonanza barley grown on Elstow soil (Pederson site).

N Applied lb/ac	Yield Grain bu/ac	Yield Straw lb/ac	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake Grain (lb/ac)	Nitrogen Uptake Straw (lb/ac)	Nitrogen Uptake Total (lb/ac)
				DRYLAND				
0	44.6	2990	0.72	11.6	0.50	39.7	15.0	54.7
50	50.4	2910	0.83	12.6	0.85	48.8	24.7	73.5
75	43.1	3178	0.66	12.7	0.95	42.0	30.2	72.2
100	49.2	3289	0.72	13.3	1.08	50.3	35.5	85.8
150	45.9	3165	0.70	16.2	1.13	57.1	35.8	92.9
200	39.4	3165	0.61	16.6	1.20	50.2	38.0	88.2
				WATER A				
0	89.4	3832	1.12	10.6	0.45	72.8	17.2	90.0
50	96.6	4680	0.99	13.9	0.73	103.1	34.2	137.3
75	100.0	4429	1.09	12.6	0.65	96.8	28.8	125.6
100	101.3	5362	0.91	14.4	0.85	112.0	45.6	157.6
150	98.6	5346	0.90	15.1	1.28	114.4	68.4	182.8
200	104.2	5417	0.93	14.2	1.38	113.6	74.8	188.4
				WATER B				
0	85.6	3882	1.06	11.2	0.43	73.6	16.7	90.3
50	100.8	5200	0.96	12.6	0.63	97.5	32.8	130.3
75	99.8	4540	1.06	12.4	0.53	95.0	24.1	119.1
100	100.6	4831	1.01	14.4	0.95	111.3	45.9	157.2
150	99.0	5435	0.88	16.2	1.33	123.2	72.3	195.5
200	100.0	5806	0.84	14.6	1.53	112.1	88.8	201.0
				WATER C				
0	89.4	4084	1.05	10.8	0.35	74.2	14.3	88.5
50	100.3	4459	1.09	13.5	0.53	104.0	23.6	127.6
75	92.0	4363	1.02	11.2	0.43	79.1	18.8	97.9
100	98.3	4921	0.96	12.6	0.83	95.1	40.9	136.0
150	105.5	5280	0.96	14.6	0.98	118.3	51.7	170.0
200	95.5	5709	0.81	14.4	1.30	105.6	74.2	179.8
				WATER D				
0	89.2	3934	1.09	10.5	0.38	71.9	15.0	86.9
50	104.4	4659	1.09	11.9	0.45	95.4	21.0	116.4
75	101.2	4591	1.06	11.4	0.55	88.6	25.3	113.9
100	112.8	5144	1.05	13.7	0.78	118.7	40.1	158.8
150	103.0	4920	1.01	15.0	1.00	118.7	49.2	167.9
200	111.1	5540	0.96	14.4	1.35	122.9	74.8	197.7
LSD (.05)	15.0	779	0.17					

[1]Grain protein based on % N at 13.5% moisture X 6.25; straw % N is on oven dry basis.

Table 1.1.7. The effect of nitrogen fertilization and irrigation scheduling on the yield and nitrogen uptake of springfield soft wheat grown on Bradwell soil (Cameron site).

N Applied lb/ac	Yield Grain bu/ac	Yield Straw lb/ac	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (lb/ac) Grain	Nitrogen Uptake (lb/ac) Straw	Nitrogen Uptake (lb/ac) Total
				DRYLAND				
0	17.7	1469	0.72	8.7	0.28	16.2	4.1	20.3
50	24.3	2267	0.65	10.8	0.33	27.6	7.5	35.1
75	24.3	2230	0.67	14.8	0.42	37.9	9.4	47.2
100	23.6	2826	0.51	15.3	0.54	38.0	15.3	53.3
150	19.8	2542	0.48	16.6	0.74	34.6	18.8	53.4
200	23.0	2727	0.51	17.3	0.82	41.9	22.4	64.3
				WATER A				
0	27.1	1790	0.91	7.9	0.25	22.5	4.5	27.0
50	37.5	2752	0.83	9.2	0.35	36.3	9.6	46.0
75	39.3	2858	0.84	9.9	0.33	41.0	9.4	50.4
100	40.2	3400	0.71	11.0	0.51	46.6	17.3	63.9
150	42.1	3432	0.74	11.7	0.67	51.9	23.0	74.8
200	37.4	3482	0.65	12.3	0.74	48.4	25.8	74.2
				WATER B				
0	26.3	1657	0.95	8.2	0.23	22.7	3.8	26.5
50	42.6	3480	0.75	9.5	0.32	42.6	11.1	53.7
75	40.7	3285	0.75	9.9	0.28	42.4	9.2	51.6
100	39.0	3705	0.64	11.0	0.42	45.2	15.6	60.7
150	39.2	4372	0.53	15.4	0.65	63.6	28.4	92.0
200	28.1	4012	0.43	15.6	0.63	46.1	25.3	71.4
				WATER C				
0	26.3	1762	0.90	8.9	0.28	24.6	4.9	29.6
50	45.6	3297	0.83	7.9	0.28	37.9	9.2	47.2
75	43.5	3106	0.84	8.2	0.30	37.6	9.3	46.9
100	47.7	4798	0.60	10.0	0.47	50.2	22.6	72.8
150	49.3	4743	0.63	10.4	0.75	54.0	35.6	89.5
200	56.7	5060	0.67	10.7	0.60	63.9	30.4	94.2
				WATER D				
0	28.7	1883	0.92	8.1	0.43	24.5	8.1	32.6
50	52.5	3900	0.82	9.2	0.53	50.8	20.7	71.5
75	50.1	3803	0.79	8.5	0.50	44.8	19.0	63.8
100	58.8	4920	0.72	10.0	0.78	61.9	38.4	100.3
150	52.8	5036	0.65	11.2	1.03	62.3	51.9	114.1
200	57.3	4960	0.71	9.9	1.10	59.7	54.7	114.3
LSD (.05)	7.9	544	0.13					

[1]Grain protein based on % N at 13.5% moisture X 5.7; straw % N is on oven dry basis.

Table 1.1.8. The effect of nitrogen fertilization and irrigation scheduling on the yield and nitrogen uptake of springfield soft wheat grown on Elstow soil (Pederson site).

N Applied lb/ac	Yield Grain bu/ac	Yield Straw lb/ac	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake Grain (lb/ac)	Nitrogen Uptake Straw (lb/ac)	Nitrogen Uptake Total (lb/ac)
				DRYLAND				
0	41.1	2836	0.87	13.0	0.73	56.2	20.7	77.0
50	40.2	2775	0.87	15.1	0.78	63.9	21.7	85.5
75	36.7	2765	0.80	14.1	0.93	54.5	25.7	80.2
100	42.6	3118	0.82	14.3	0.88	64.1	27.4	91.6
150	36.9	2744	0.81	16.1	1.05	62.5	28.8	91.4
200	38.6	2936	0.79	15.6	1.08	63.4	31.7	95.1
				WATER A				
0	64.9	4347	0.90	10.2	0.70	69.7	30.4	100.1
50	66.6	4969	0.81	10.7	1.03	75.0	51.2	126.2
75	69.3	5116	0.82	10.0	1.10	73.0	56.3	129.2
100	66.0	4910	0.81	11.7	1.23	81.3	60.4	141.7
150	68.0	5174	0.79	10.7	1.35	76.6	69.9	146.4
200	67.8	5452	0.75	10.8	1.35	77.1	73.6	150.7
				WATER B				
0	56.9	4190	0.82	10.2	0.68	61.1	28.5	89.6
50	59.4	4824	0.74	10.8	1.10	67.5	53.1	120.6
75	59.7	4911	0.73	10.8	1.20	67.9	58.9	126.8
100	58.9	5160	0.69	11.3	1.18	70.1	60.9	131.0
150	57.6	5027	0.69	11.2	1.43	67.9	71.9	139.8
200	54.6	4946	0.67	12.2	1.40	70.1	69.3	139.4
				WATER C				
0	67.0	5005	0.81	8.4	0.58	59.2	29.0	88.3
50	66.4	5275	0.76	10.8	0.90	75.5	47.5	123.0
75	66.8	5473	0.74	9.5	0.98	66.8	53.6	120.4
100	69.1	5723	0.73	9.6	1.23	69.8	70.4	140.2
150	63.3	5711	0.67	10.5	1.28	70.0	73.1	143.1
200	62.0	5874	0.64	11.3	1.38	73.8	81.1	154.8
				WATER D				
0	68.3	4980	0.83	8.3	0.60	59.7	29.9	89.6
50	68.3	5372	0.77	9.5	0.93	68.3	50.0	118.3
75	70.3	5735	0.74	9.6	1.43	71.0	82.0	153.1
100	66.8	5859	0.68	10.5	1.28	73.8	75.0	148.8
150	69.0	6356	0.65	11.1	1.53	80.6	97.3	177.9
200	68.4	6183	0.67	11.0	1.25	79.2	77.3	156.5
LSD (.05)	4.9	435	0.09					

[1]Grain protein based on % N at 13.5% moisture X 5.7; straw % N is on oven dry basis.

Table 1.1.9. The effect of nitrogen fertilization and irrigation scheduling on the yield and nitrogen uptake of Midas rapeseed grown on Bradwell soil (Cameron site).

N Applied lb/ac.	Yield Grain bu/ac	Yield Straw lb/ac	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Grain % oil	Nitrogen Uptake Grain (lb/ac)	Nitrogen Uptake Straw (lb/ac)	Nitrogen Uptake Total (lb/ac)
				DRYLAND					
0	9.2	1677	0.28	20.4	0.48	43.5	15.0	8.1	23.1
50	14.9	2361	0.31	24.0	0.58	41.8	28.6	13.7	42.3
75	13.1	2275	0.29	23.6	0.50	39.5	24.7	11.4	36.1
100	11.9	2347	0.25	25.6	0.63	39.4	24.4	14.8	39.2
150	15.4	2852	0.27	25.2	0.73	39.7	31.1	20.8	51.9
200	13.2	2438	0.28	26.0	1.03	39.9	27.5	25.1	52.6
				WATER A					
0	13.8	1774	0.39	17.3	0.43	45.6	19.1	7.6	26.7
50	20.4	2752	0.37	21.4	0.55	44.5	34.9	15.1	50.1
75	21.3	2987	0.36	20.5	0.50	43.7	34.9	14.9	49.9
100	21.0	3194	0.34	23.1	0.65	42.8	38.8	20.8	59.6
150	26.4	4051	0.33	24.2	0.90	40.6	51.1	36.5	87.6
200	22.3	3694	0.30	24.3	1.08	41.8	43.4	39.9	83.3
				WATER B					
0	14.9	1959	0.38	17.7	0.40	47.6	21.1	7.8	28.9
50	21.1	3102	0.34	19.8	0.35	43.5	33.4	10.9	44.3
75	25.6	3437	0.37	18.2	0.38	44.8	37.3	13.1	50.3
100	31.3	3890	0.40	20.0	0.33	42.8	50.1	12.8	62.9
150	28.9	3784	0.38	21.1	0.55	42.5	48.9	20.8	69.6
200	28.8	3653	0.39	23.0	0.83	42.7	53.0	30.3	83.3
				WATER C					
0	17.3	2037	0.42	17.7	0.35	47.3	24.5	7.1	31.6
50	31.2	3832	0.41	17.1	0.28	47.7	42.7	10.7	53.4
75	35.4	4128	0.43	16.8	0.38	48.6	47.6	15.7	63.3
100	43.7	4762	0.46	18.6	0.43	45.8	65.0	20.5	85.5
150	47.4	4980	0.48	22.3	0.58	46.3	84.6	28.9	113.5
200	41.0	4667	0.44	21.8	0.80	45.9	71.5	37.3	108.8
				WATER D					
0	17.6	2292	0.38	17.1	0.45	48.6	24.1	10.3	34.4
50	32.3	3864	0.42	17.3	0.30	47.1	44.6	11.6	56.2
75	36.6	4344	0.42	17.7	0.40	49.3	51.8	17.4	69.2
100	51.0	5453	0.47	18.4	0.38	48.2	75.1	20.7	95.8
150	44.6	5016	0.44	21.1	0.48	44.3	75.3	24.1	99.4
200	41.4	4956	0.42	20.9	0.78	43.4	69.2	38.7	107.9
LSD(.05)	5.8	632	0.05						

[1]Grain protein based on % N at 13.5% moisture X 6.25; straw % N on oven dry basis.

Table 1.1.10. The effect of nitrogen fertilization and irrigation scheduling on the yield and nitrogen uptake of Midas rapeseed grown on Elstow soil (Pederson site).

N Applied lb/ac.	Yield Grain bu/ac	Yield Straw lb/ac	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Grain % oil	Nitrogen Uptake Grain (lb/ac)	Nitrogen Uptake Straw (lb/ac)	Nitrogen Uptake Total (lb/ac)
				DRYLAND					
0	16.3	2379	0.34	24.0	0.75	41.0	31.3	17.8	49.1
50	13.3	2013	0.33	24.0	1.15	40.8	25.5	23.2	48.7
75	14.6	2168	0.34	22.0	1.28	40.1	25.7	27.8	53.5
100	14.0	2084	0.34	23.1	1.18	40.2	25.8	24.6	50.5
150	14.5	2236	0.32	22.9	1.30	39.4	26.6	29.1	55.6
200	11.5	1895	0.31	22.9	1.33	40.1	21.1	25.2	46.3
				WATER A					
0	34.1	3235	0.53	18.4	0.63	46.6	50.2	20.4	70.6
50	41.3	3666	0.57	19.1	1.08	44.8	63.1	39.6	102.7
75	32.8	3028	0.54	19.3	0.95	44.2	50.6	28.8	79.4
100	49.9	4527	0.55	20.5	1.00	44.5	81.8	45.3	127.1
150	44.9	4064	0.56	19.8	1.28	43.7	71.1	52.0	123.2
200	40.3	3584	0.56	20.7	1.53	43.9	66.7	54.8	121.6
				WATER B					
0	29.9	3275	0.46	16.9	0.88	46.4	40.4	28.8	69.3
50	37.2	3641	0.51	18.6	0.70	45.0	55.4	25.5	80.8
75	40.2	4379	0.47	17.8	0.80	45.4	57.3	35.0	92.3
100	41.0	4037	0.51	20.0	0.85	44.4	65.6	34.3	99.9
150	40.9	4268	0.48	20.2	1.08	43.4	66.1	46.1	112.2
200	48.2	4666	0.51	20.5	1.08	43.8	79.1	50.4	129.5
				WATER C					
0	38.4	4160	0.46	16.9	0.53	47.5	51.9	22.1	74.0
50	42.8	4181	0.51	18.0	0.65	45.6	61.6	27.2	88.8
75	43.9	4314	0.51	19.1	0.70	45.1	67.1	30.2	97.3
100	45.8	4987	0.47	19.6	1.05	44.1	71.8	52.4	124.2
150	43.8	4497	0.49	19.8	1.08	43.6	69.4	48.6	118.0
200	41.5	4469	0.48	20.7	0.95	42.4	68.7	42.5	111.2
				WATER D					
0	39.6	3912	0.51	16.8	0.58	46.5	53.2	22.7	75.9
50	47.7	4569	0.52	18.2	0.75	45.1	69.5	34.3	103.7
75	43.5	4440	0.49	17.8	0.75	44.9	61.9	33.3	95.2
100	47.2	4674	0.50	19.3	1.00	45.8	72.9	46.7	119.6
150	55.7	5532	0.50	19.8	1.13	43.9	88.2	62.5	150.8
200	44.6	4265	0.52	19.5	1.08	44.1	69.6	46.1	115.6
LSD (.05)	8.2	770	0.06						

[1]Grain protein based on % N at 13.5% moisture X 6.25; straw % N on oven dry basis.

On the Bradwell soil large increases in protein content of all three crops were associated with nitrogen addition for both the dryland and water A treatments. For barley and soft wheat on the water B, C and D treatments large increases in protein were not obtained until 100 lbs N/acre or more were added. In fact, as has been noted in previous years small additions of fertilizer nitrogen can actually result in a decrease in protein content of soft wheat or barley if large yield increases are being obtained. Rapeseed oil content was reduced significantly by nitrogen additions for the dryland and water A and B treatments. Where irrigation scheduling was optimum (water C and D treatments) then nitrogen addition did not result in significant reductions in oil contents until the rate of applied nitrogen had exceeded 100 lbs N/acre.

For the Elstow soil where the soil nitrogen level was very high significant nitrogen responses were only obtained for barley and rapeseed and for water treatments where little or no moisture stress occurred. With barley, the protein content was increased significantly by nitrogen additions for all levels of water management. With wheat, increases in protein content due to nitrogen were noted for the dryland, water C and water D treatments. With rapeseed, the protein content was increased and oil content sharply reduced by nitrogen application for all water management treatments except the dryland treatment.

As noted previously the Elstow soil had been fallowed during 1974 whereas the Bradwell soil had been cropped in 1974. It is interesting to make comparisons of the upper yield levels obtained for these two previous past management practices. For barley and rapeseed the yields of fallow and stubble seeded plots were essentially equated when both nitrogen and water management were optimum (i.e. water C and water D treatments and

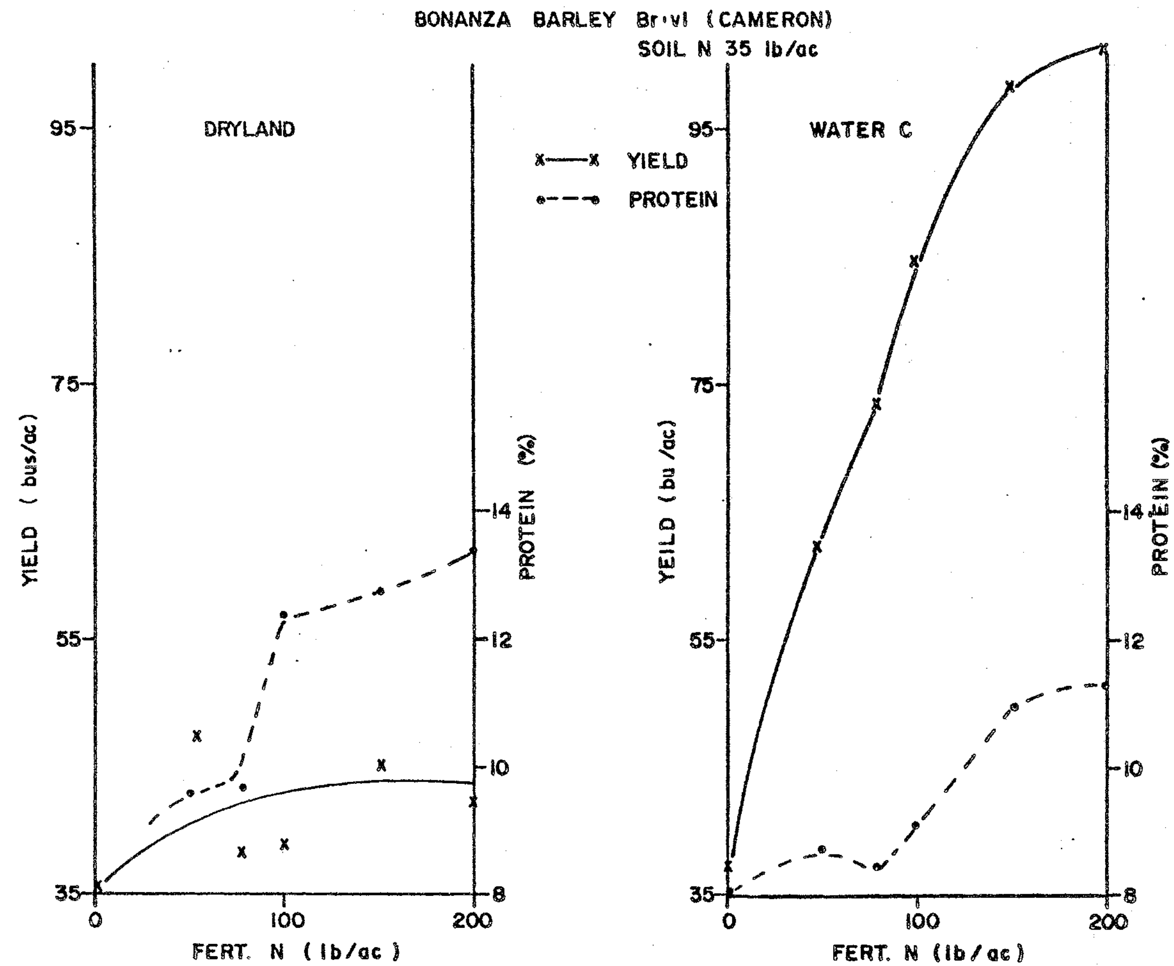

Figure 1.1.1. The effect of nitrogen fertilization and water regime on yield and protein of barley.

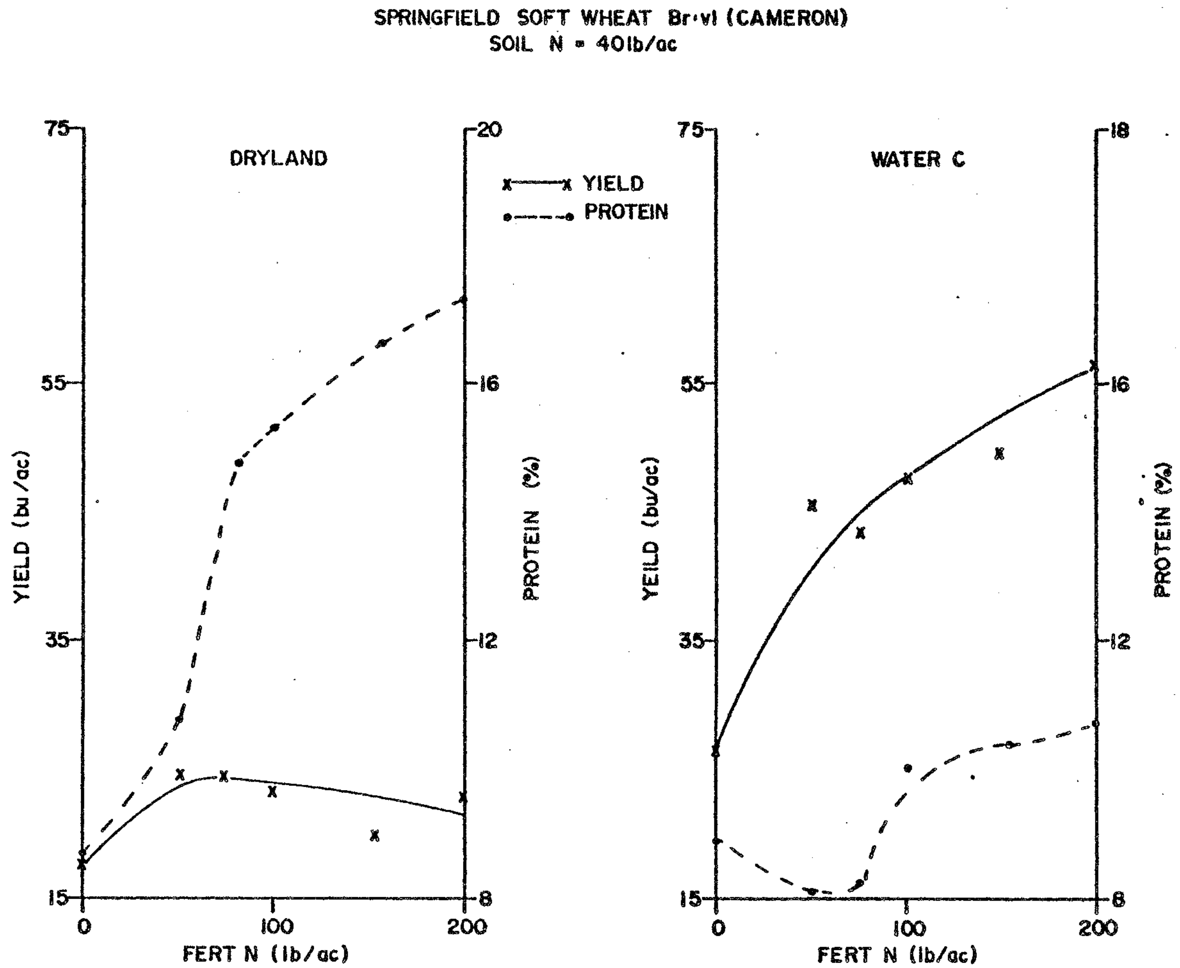

Figure 1.1.2. The effect of nitrogen fertilization and water regime on yield and protein content of soft wheat.

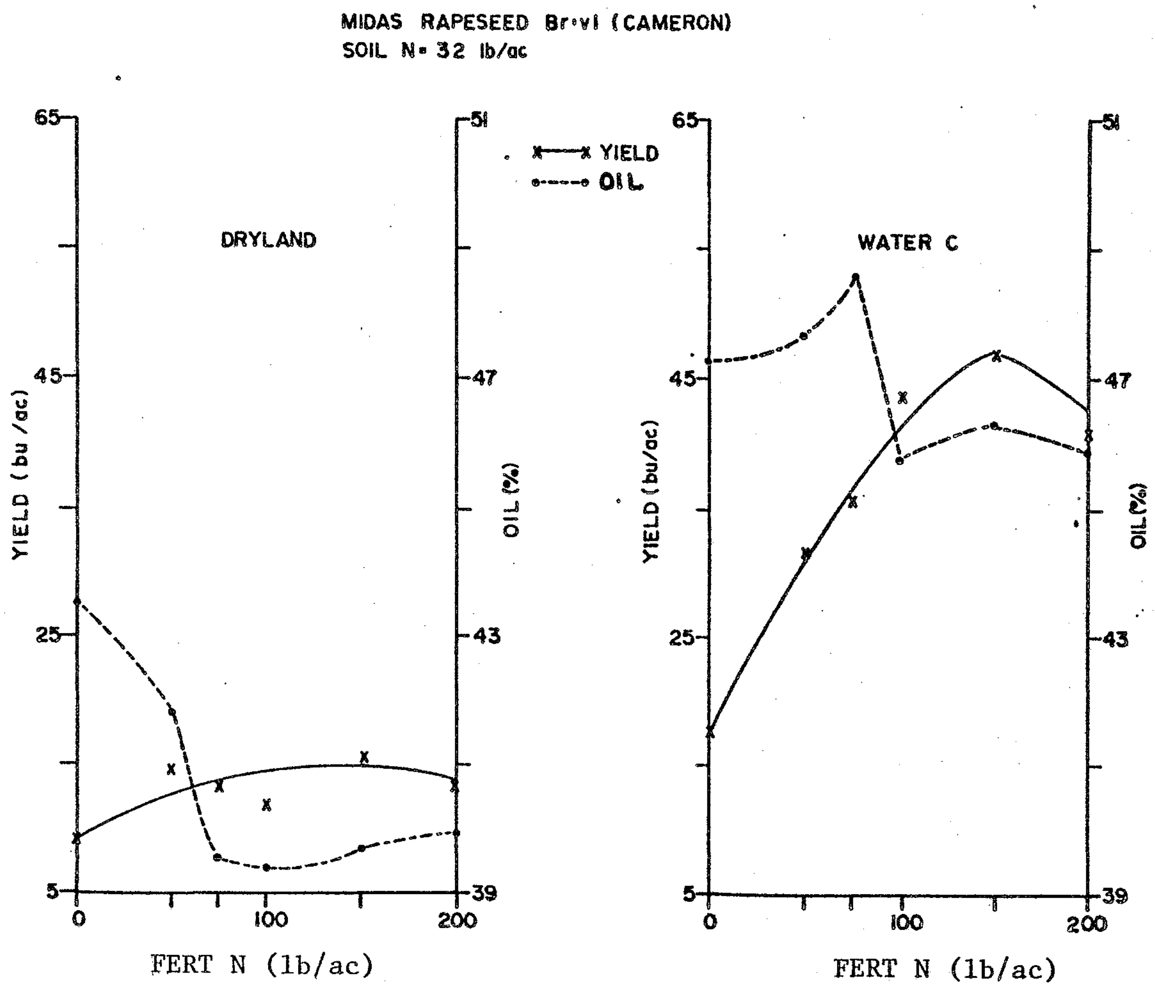

Figure 1.1.3. The effect of nitrogen fertilization and water regime on the yield and oil content of rapeseed.

nitrogen rate of 150 lbs N/acre or greater). For soft wheat yields of the fallow plot exceeded that of the stubble plot for all nitrogen and water treatments. This was likely due to a green foxtail infestation on the stubble plot for which there was no chemical control available. These observations essentially show that the rather large differences between stubble and fallow seeded crops that have been observed for many years are due largely to factors of nitrogen, water, weed control and seedbed preparation. If these factors can be suitably managed then there appears to be no reason why stubble seeded crops cannot equal that of fallow seeded crops.

Effects of Irrigation Scheduling

The irrigation treatments used and water applications made have been presented in the previous section (Tables1.1.2, 1.1.3 and 1.1.4).

The seasonal water use patterns(Table 1.1.11) indicate no consistent trend with respect to individual crops on the two soils. This is in contrast to data of previous years where water use by rapeseed slightly exceeded that of the other two crops.

The relative ratings of the various irrigation treatments (Table 1.1.12) show clearly the necessity for early application of irrigation water. In all cases water treatment C and D resulted in significantly greater yields than any of the other irrigation schedules.

Further data on the effects of irrigation scheduling of the yields of the three crops is provided in Figures 1.1.4 to 1.1.6. On the nitrogen deficient Bradwell soil yields of soft wheat and rapeseed were markedly reduced by moisture stresses early in the growing season (water treatments A and B) where either 100 or 200 lbs N/acre were applied. For barley the same effects were noted but the yield depressions due to early moisture

Table 1.1.11. Seasonal water use of barley, soft wheat and rapeseed.

Crop	Water Schedula	Rainfall + Irrigation	ΔS*	Total Water Use
			inches	
		Elstow soil (Pederson site)		
Barley	Dryland	6.3	3.8	10.1
	A	17.9	-1.3	16.6
	B	17.6	-0.8	16.8
	C	16.7	-0.8	15.9
	D	20.1	-1.2	18.9
Soft Wheat	Dryland	6.3	5.7	12.0
	A	17.9	-0.6	17.3
	B	18.0	-0.1	17.9
	C	16.7	1.1	17.8
	D	20.1	-0.2	19.9
Rapeseed	Dryland	6.3	4.6	10.9
	A	13.2	1.2	14.4
	B	13.3	1.8	15.1
	C	12.5	3.3	15.8
	D	16.3	0.6	16.9
		Bradwell soil (Cameron site)		
Barley	Dryland	6.2	4.6	10.8
	A	9.6	2.9	12.5
	B	9.4	1.9	11.3
	C	14.6	-1.8	12.8
	D	14.6	-0.7	13.9
Soft Wheat	Dryland	6.2	4.8	11.0
	A	12.8	-0.6	12.2
	B	12.6	-0.2	12.4
	C	14.6	0.2	14.8
	D	17.8	1.7	19.5
Rapeseed	Dryland	6.2	5.5	11.7
	A	12.8	0.5	13.3
	B	12.6	0.3	12.9
	C	14.6	2.1	16.7
	D	17.8	2.4	20.2

* ΔS = change in soil moisture content (Spring-fall).

**Total water use = rainfall + irrigation + ΔS.

Table 1.1.12. Relative rating of yields from various irrigation regimes.

	Bradwell soil (Cameron site)	Elstow soil (Pederson site)
Barley	Dry<<A[1]=B<C=D	Dry<<A=B<C<D
Soft Wheat	Dry<<A=B<C=D	Dry<<B<A=C=D
Rapeseed	Dry<<A=B<C=D	Dry<<A=B=C<D

[1] Dry = Dryland

Water A = missed first irrigation

Water B = missed second irrigation

Water C = missed third irrigation

Water D = received all irrigations

[2] As interpreted from visual inspection of nitrogen response curves for the various irrigation regimes.

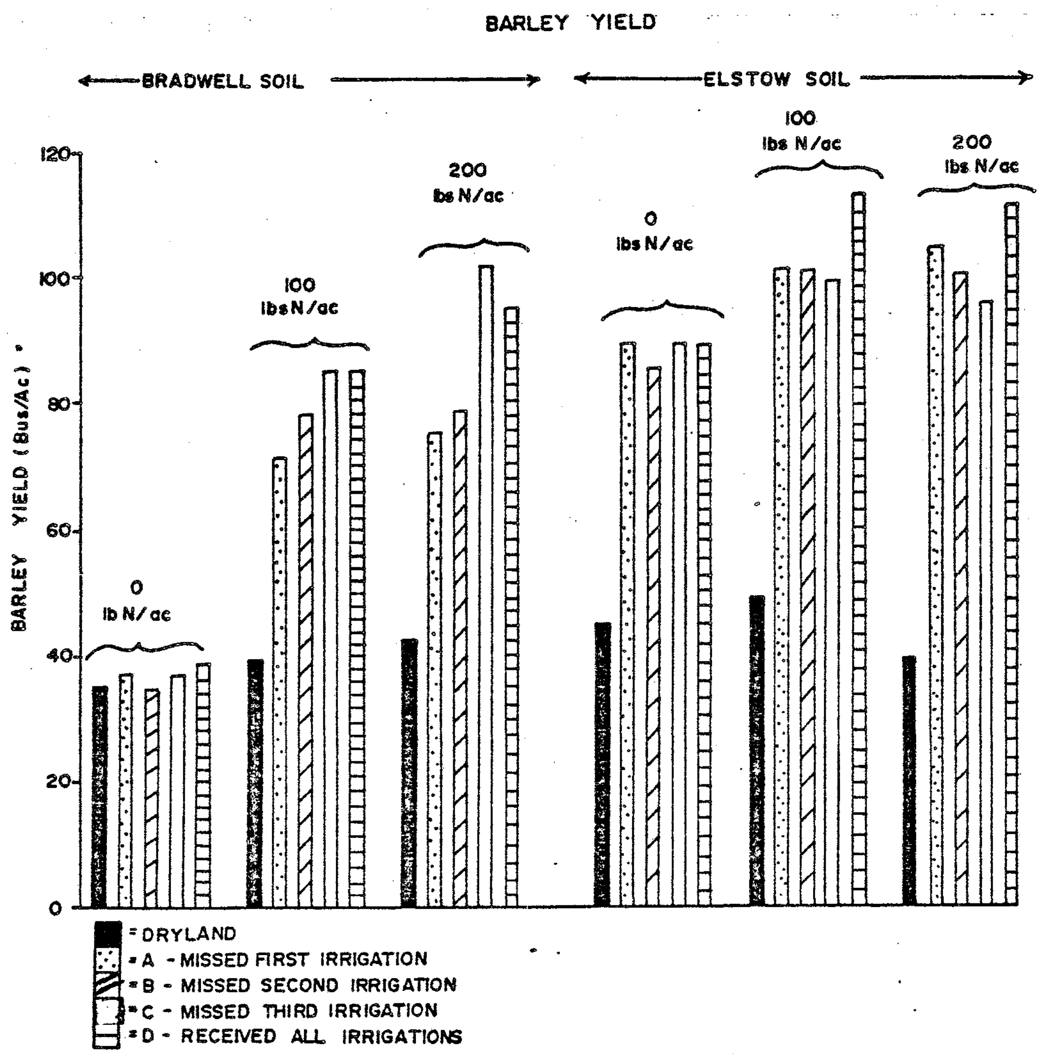

Figure 1.1.4. The effect of different moisture stresses on the yield of barley with different nitrogen rates.

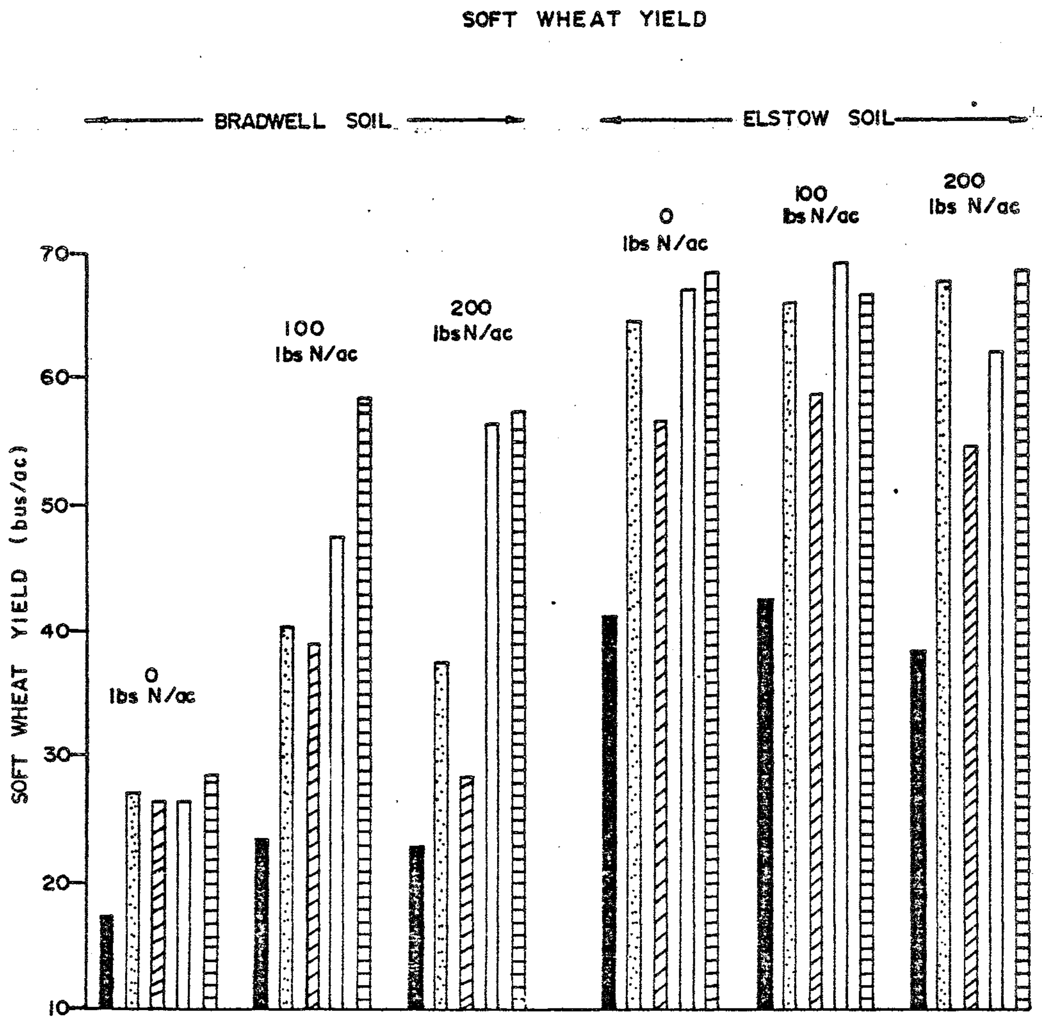

Figure 1.1.5. The effect of moisture stresses on the yield of soft wheat with different rates of nitrogen. (See Figure 1.1.4. for legend).

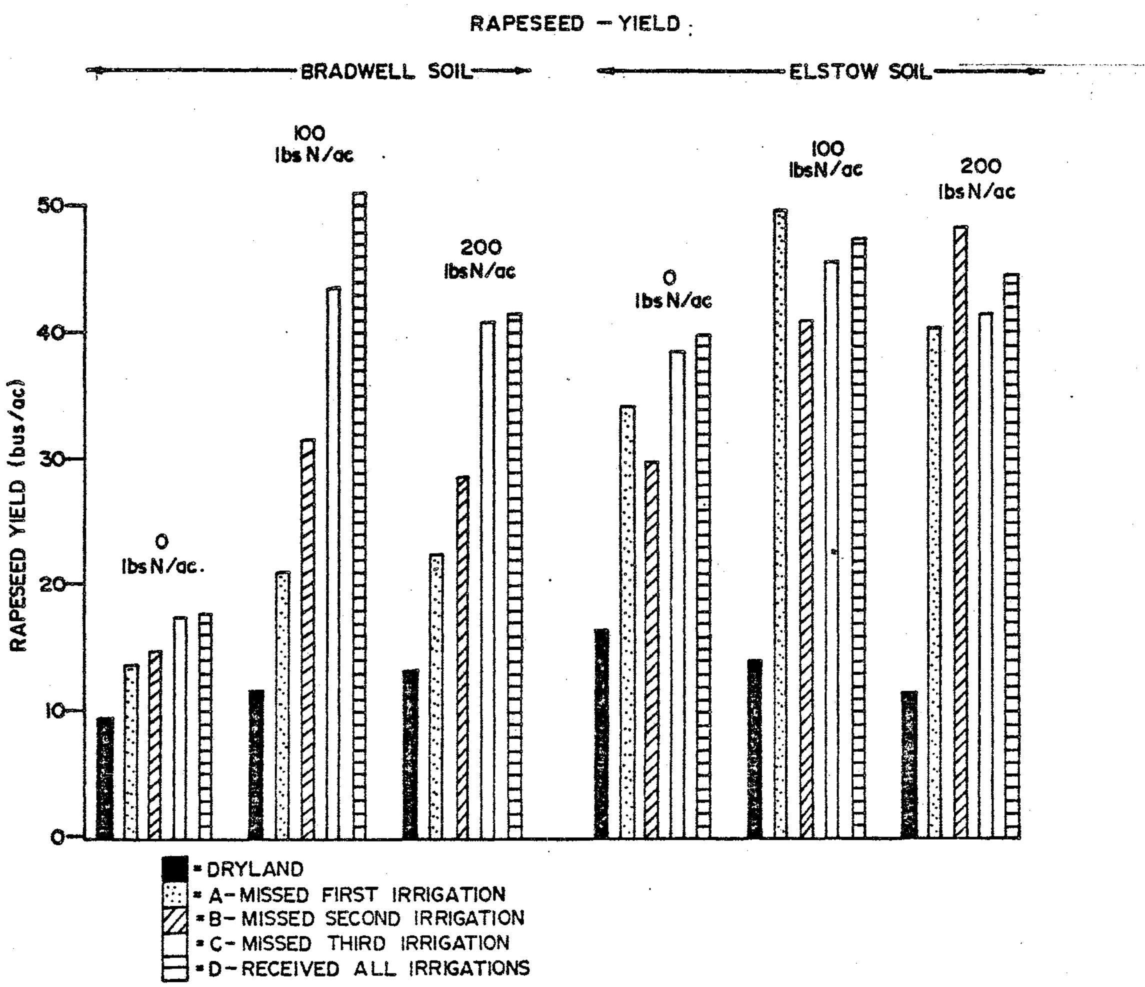

Figure 1.1.6. The effect of different moisture stresses on the yield of rapeseed with different rates of nitrogen.

stress were not as marked as for the other two crops. On the Elstow soil where soil nitrogen supplies were adequate the effects of irrigation scheduling were not as marked for rapeseed and barley. With soft wheat, a significant yield reduction occurred when the second irrigation was omitted (water treatment B).

The protein contents (Figures 1.1.7 to 1.1.9) of all crops was highest for the dryland treatment, with the exception of the 100 lbs N/acre rate on the Elstow soil for barley. In general, for the Bradwell soil moisture stresses early in the growing season resulted in the highest protein content. This effect was most marked with soft wheat and rapeseed. On the Elstow soil moisture stress at various times throughout the growing season had relatively less effect on the protein content of crops.

The oil content of rapeseed (Figure 1.1.10) was lowest for the dryland treatment at both locations. Moisture stresses early in the growing season generally resulted in the lowest oil content. This was most evident for the 100 and 200 lbs N/acre rates on the Bradwell soil.

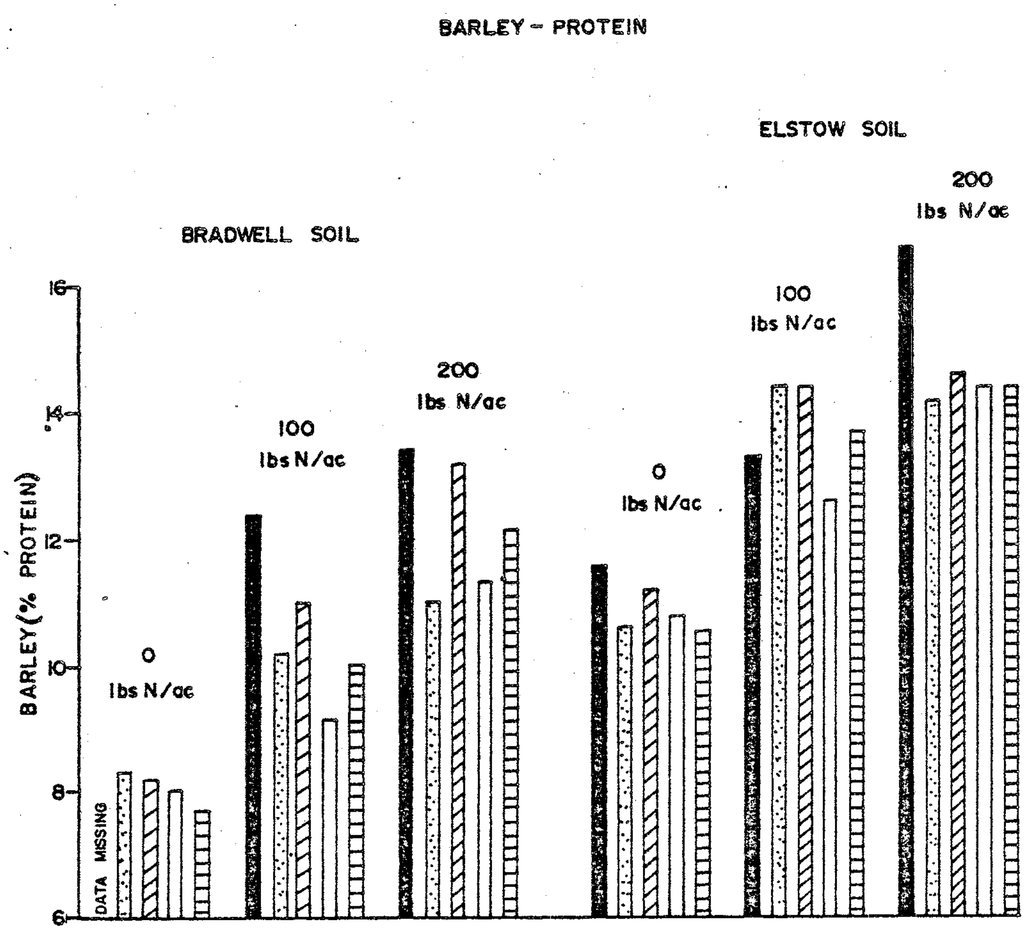

Figure 1.1.7. The effect of different moisture stresses on the protein content of barley with different rates of nitrogen. (See Figure 1.1.4. for legend).

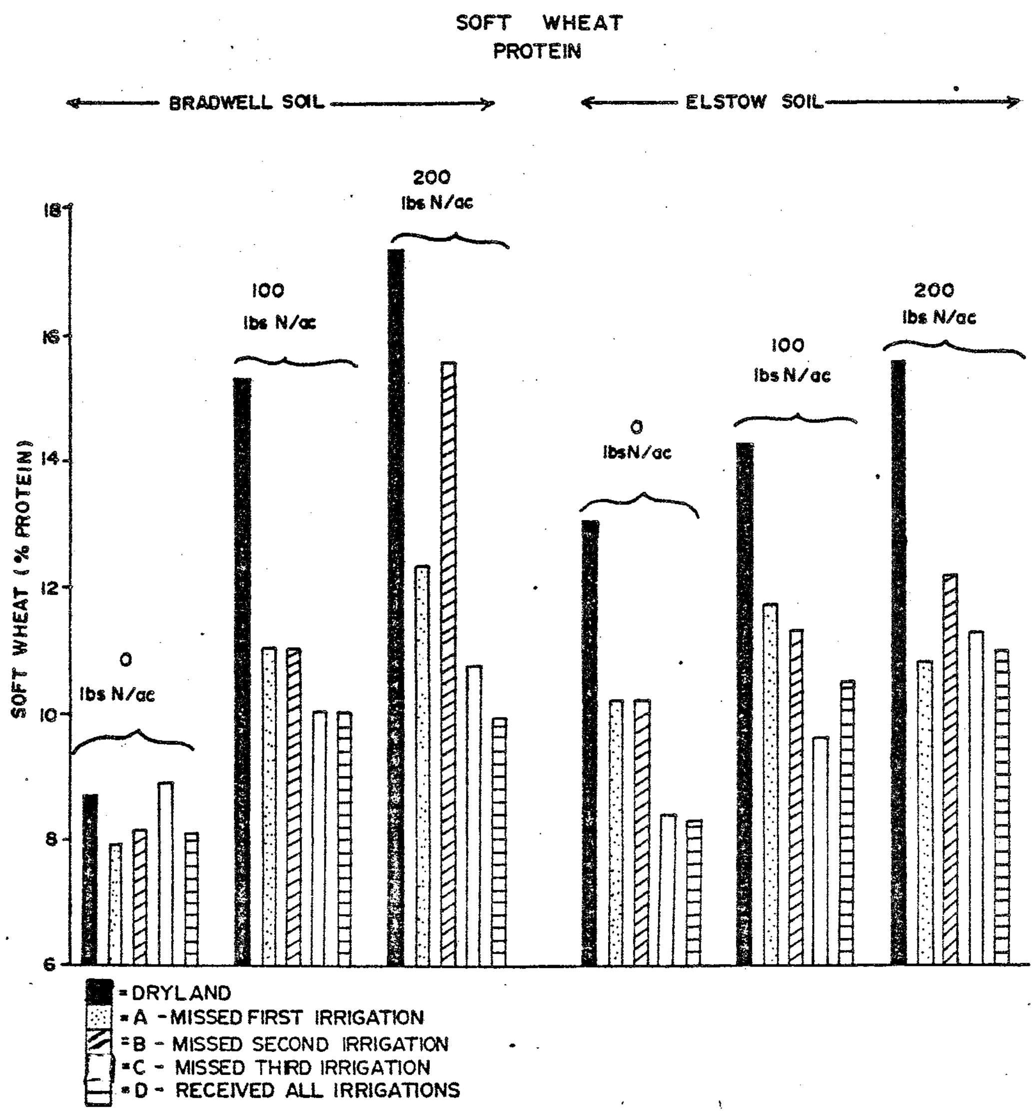

Figure 1.1.8. The effect of different moisture stresses on the protein content of soft wheat with different rates of nitrogen.

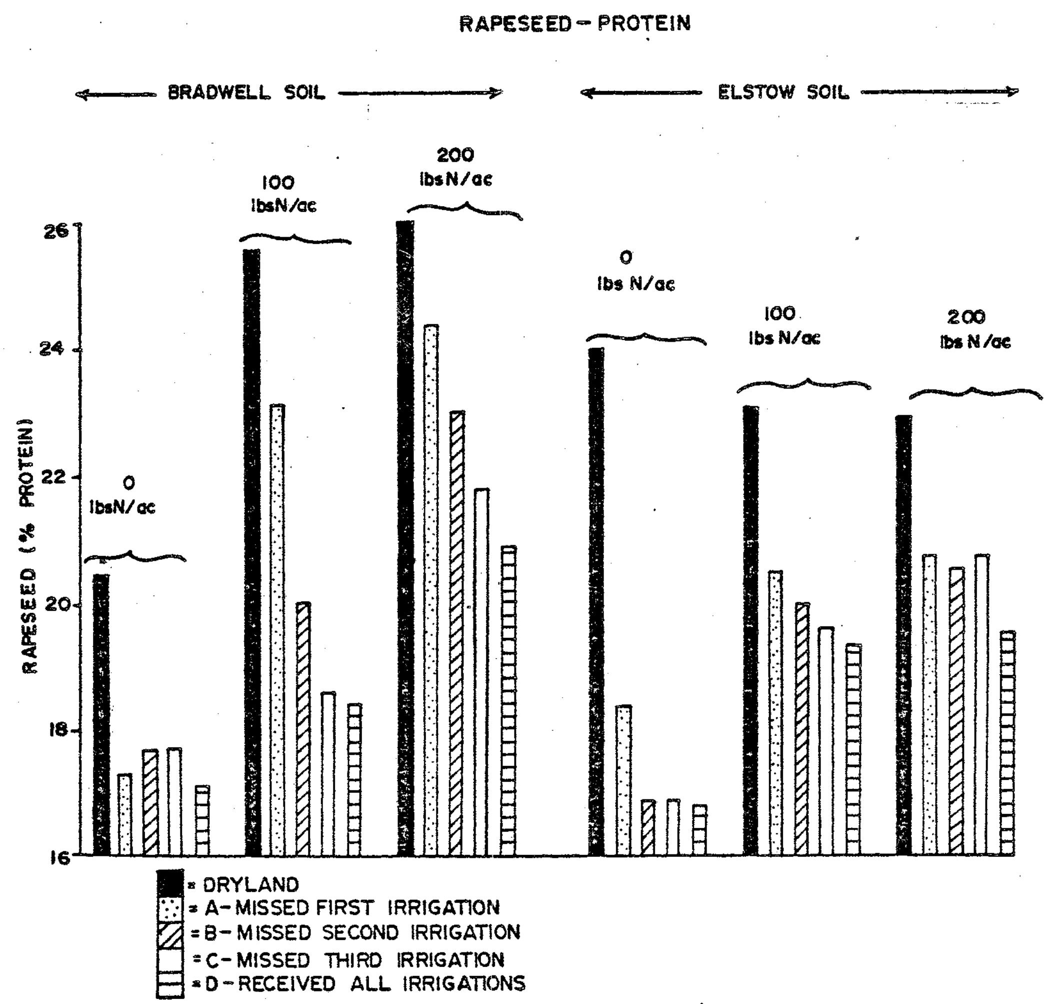

Figure 1.1.9. The effect of different moisture stresses on the protein content of rapeseed with different rates of nitrogen.

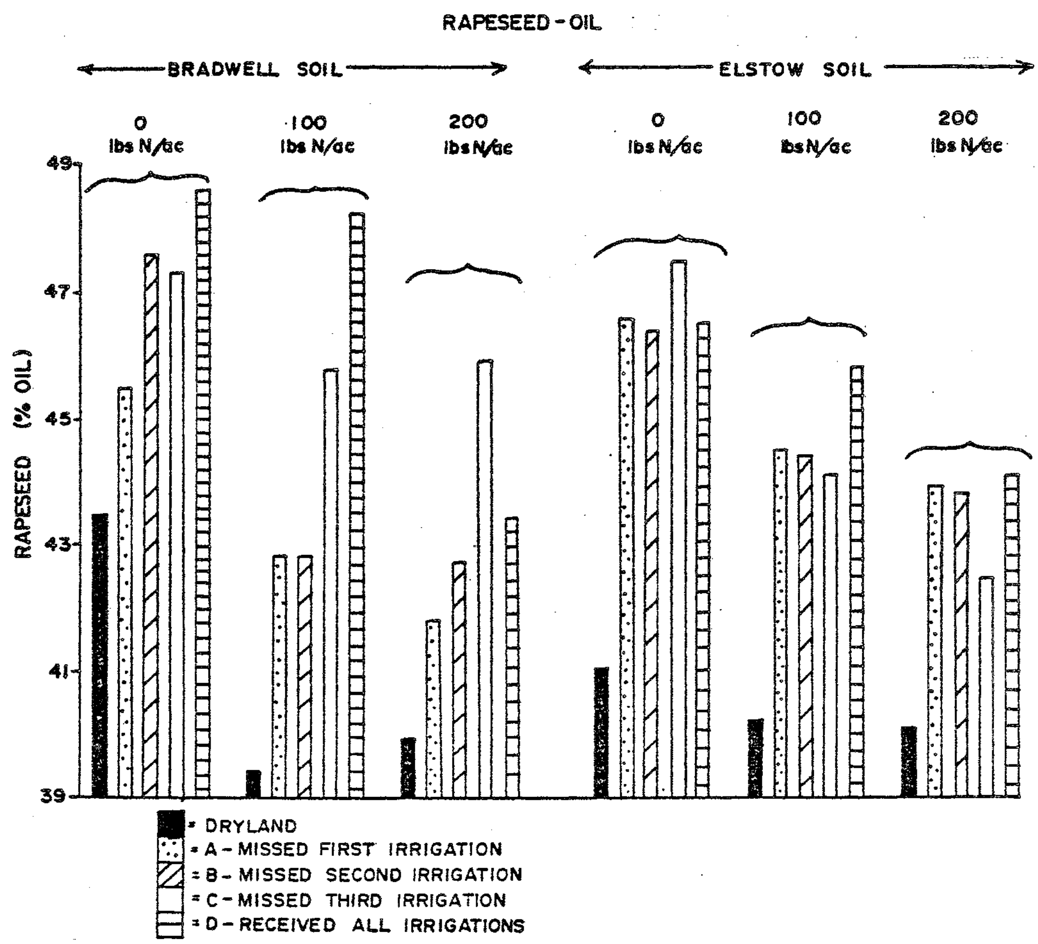

Figure 1.1.10. The effect of different moisture stresses on the oil content of rapeseed with different rates of nitrogen.

1.2 Residual nitrogen at the end of the growing season.

To determine the possibility of residual response to nitrogen in subsequent years and to determine the potential for downward movement of nitrate nitrogen to the groundwater, a detailed fall soil sampling program was conducted on both major irrigation experiments. Samples were taken from the dryland, water A and water D treatments and from the zero and 200 lb N per acre rate for all three crops. Two soil cores (2 inches diameter) were removed from each replicate of the above treatments for each crop and composited. Samples from the four replicates were kept separate, air dried and analysed for nitrate nitrogen content to allow a measure of variability. The results are presented in Table 1.2.1.

For the Elstow soil residual nitrogen from the 200 lb N per acre application was measured for all crop and water treatments. For the dry land treatment most of the residual nitrogen was in the top two feet of the soil profile but there was some evidence of minor amounts of residual nitrogen below that depth for barley and soft wheat. In the water A and water B treatments, much of the residual nitrogen was in the second, third or fourth foot of the soil profile.

For the Bradwell soil residual nitrogen was also measured for all crop and water treatment. For the dry land treatment, the location of the residual nitrogen was similar to that for the Elstow soil. For rapeseed and soft wheat the majority of the residual nitrogen in the water A and water B treatments was below the one foot depth. For barley, the residual nitrogen in both irrigation treatments appeared to be more uniformly distributed throughout the soil profile.

The results of the residual nitrogen sampling for 1975, agree fairly closely with that obtained in 1974. In both 1974 and 1975, there was

Table 1.2.1. Residual nitrate nitrogen levels from various rates of nitrogen application and irrigation treatments.

Depth	Dryland		Water A		Water D	
	N Rate (lb/ac)					
(inches)	0	200	0	200	0	200
	lbs NO_3=N/acre*					
ELSTOW: L						
Barley						
0-6	8±1	57±24	5±1	11±5	6±1	11±2
6-12	6±1	80±58	2±1	7±3	3±0	8±2
12-24	7±1	89±34	5±2	19±14	6±0	16±4
24-36	7±1	19±4	5±1	36±21	4±0	17±8
36-48	9±2	18±8	6±3	22±6	6±1	27±17
Soft Wheat						
0-6	11±2	65±26	6±2	20±13	4±1	15±3
6-12	7±1	71±57	4±2	10±5	2±0	6±3
12-24	11±2	62±17	5±3	24±8	5±1	7±3
24-36	11±3	39±26	4±2	66±24	3±2	39±39
36-48	21±8	31±7	9±5	46±8	6±2	27±18
Rapeseed						
0-6	10±1	65±6	7±2	17±7	5±1	14±8
6-12	6±2	103±12	2±1	8±5	2±0	6±3
12-24	12±4	53±17	5±1	57±37	5±1	45±17
24-36	9±5	14±3	15±14	36±19	4±2	23±11
36-48	16±9	17±3	17±4	14±2	5±2	19±11
BRADWELL: VL						
Barley						
0-6	9±2	43±6	9±2	28±20	8±1	16±11
6-12	4±1	48±22	5±2	27±15	4±1	6±2
12-24	5±1	27±7	7±2	25±14	5±1	19±19
24-36	8±4	12±6	7±1	13±1	7±3	10±2
36-48	21±7	20±7	10±2	16±6	15±4	14±4
Soft Wheat						
0-6	9±2	36±24	9±3	15±4	8±1	19±10
6-12	4±0	37±40	5±1	7±4	4±1	8±4
12-24	5±1	21±12	7±1	18±6	6±1	33±17
24-36	7±2	18±13	6±2	29±23	6±1	20±12
36-48	15±3	20±11	11±7	19±6	10±4	16±3
Rapeseed						
0-6	12±3	48±17	10±1	23±11	9±1	13±1
6-12	5±1	58±33	5±1	7±2	6±1	10±1
12-24	11±7	30±18	9±1	51±52	9±1	26±20
24-36	7±1	14±8	9±3	58±39	10±2	14±3
36-48	16±6	16±6	12±2	16±4	17±3	18±4

* Mean± Standard Deviation

more evidence of leaching of nitrate below the four foot depth than was obtained in similar studies conducted from 1971 to 1973. The presence of significant quantities of nitrate in the fourth foot is taken as evidence that some nitrogen may have moved beyond that depth.

Attention is drawn to the degree of variation. On the control plots where the amount of nitrogen was small the degree of variability is very low. However, where residual nitrogen was being measured the variability was extremely high. Thus, it is possible to locate the position of the residual nitrogen but the measurement can only be considered as semi-quantitative.

1.3 Survey of alfalfa fields.

INTRODUCTION

From 1971 to 1973 experiments were conducted on alfalfa to determine requirements for fertilizer phosphorus, potassium, sulfur and boron. No responses to potassium, sulfur or boron were obtained. In one case where the A horizon had been removed by leveling operations strong responses to fertilizer phosphorus were obtained. In other locations, where the A horizon was intact, there was no response to fertilizer phosphorus even at sites where soil analysis would indicate a need for phosphorus fertilizer.

In the work from 1971 to 1973, all fertilizer material was surface broadcast on established stands of alfalfa. In 1974, two experiments were established in which fertilizer phosphorus was applied to the soil prior to stand establishment and was incorporated by rototilling. The rototilling operation resulted in a loose seed bed which resulted in deep seeding and stand failures. Therefore, both the experiments were abandoned.

Therefore, in 1975 it was decided to conduct a survey of alfalfa fields throughout the irrigation area to determine if any other nutrients might be limiting plant growth and to provide information to direct any further field experiments.

EXPERIMENTAL METHODS

Ten field sites were established to provide a range in soil conditions from Asquith sandy loam to Elstow clay loam and a range in age of stand. The location and major characteristics of the sites selected are presented in Table 1.3.1.

At each site three replicates each ten feet by ten feet were selected

Table 1.3.1. Site characteristics for alfalfa survey.

Site No.	Location	Soil	Year stand Estd.	Irrigation Type
1	NW32-27-7-3	A:sl	1969	Border Dike
2	NW32-27-7-3	A:sl	1969	Border Dike
3	SW5-28-7-3	A:sl	1970	Sprinkler
4	SE21-28-7-3	E:l	1974	Border Dike
5	NE20-28-7-3	E:l	1971	Corrugations
6	NE29-28-7-3	E:cl	1969	Border Dike
7	PFRA Farm	Br:vl	1974	Sprinkler
8	SE33-29-7-3	Br:fl	1972	Border Dike
9	Agric. Can. Plots	Br:vl	1969	Sprinkler
10	NE16-28-7-3	E:l	1969	Border Dike

for sampling. Within each replicate the top six inches of twenty plants was taken at the one-tenth bloom stage of the alfalfa for each of two cuttings. These samples were placed in paper bags and transferred immediately to the field laboratory where they were dried in a forced draft oven at 65°C for 48 hours. The top six inch portion of the plant was utilized for plant nutrient analysis to allow comparison with literature values.

In addition, yield estimates were obtained at each site by taking a three square yard sample in each replicate. A wet weight of the sample was taken immediately and a one hundred gram subsample of the wet material was dried at 65 C for 48 hours and the dry weight obtained.

Within each replicate six to eight soil cores were taken to the six inch depth. These cores were composited to obtain one sample per replicate. The samples were air dried immediately prior to laboratory analysis.

Soil and plant analyses were all conducted by the Saskatchewan Soil Testing Laboratory. Soil analyses included pH, conductivity, and available nitrogen phosphorus, potassium and sulfur. Plant analyses included total phosphorus, iron, manganese and zinc.

Samples were taken in the field at the time of two harvest cuttings (i.e. June and August). At the time of sampling, individual plants in each replicate were excavated to determine by visual observation the degree of nodulation. The nodulation was rated according to the following scale: zero = no nodulation, one = very few, two = few, three = several, four = many and five = very many.

RESULTS AND DISUCSSION

The results of the soil and plant analysis and yield data are presented in Tables 1.3.2 and 1.3.3. There appeared to be no significant relationship between soil analysis and yield. A wide range of available phosphours levels were obtained from the lowest category in current soil test bench marks up to the highest category. The range of potassium values was not as great. Sites one and two have potassium levels where current recommendations would suggest a 30 lb/K_2O per acre annual application for alfalfa.

The plant analysis data (Table 1.3.3) show adequate quantities of phosphorus, manganese and zinc according to published literature values (Table 1.3.4).

The values obtained for plant iron were not reliable and hence were not reported. Further investigation of the iron nutrition will definitely be required.

There did not appear to be any definite relationship between plant values and soil values for phosphorus, iron and zinc. For manganese, there was a definite relationship between plant manganese and soil pH. The regression equations relating plant manganese to soil pH where as follows:

For cut one:

Plant manganese = 403 - 44.93 X pH (R=-0.74);

For cut two:

Plant manganese = 512 - 62.4 X soil pH (R=-0.80).

There was a strong relationship between the year of stand establishment and the degree of nodulatin noted. Stands established in 1974, exhibited a high degree of nodulation whereas many of the stands established in 1969, showed very few nodulals present. In all cases where nodules were observed, they were judged to be effectively fixing nitrogen as determined by the red coloration of the interior of the nodule.

Table 1.3.2. Soil analyses from alfalfa survey sites (0-6" depth).

Site	Soil Type	Rep.	pH	Salinity mmhos/cm	NO_3^--N	P	K
					---------lbs/acre--------		
			Samples Taken June/75 (Cut 1)				
1	A:sl	1	7.9	0.3	5	18	235
		2	7.9	0.3	5	16	205
		3	7.9	0.2	5	17	185
2	A:sl	1	8.0	0.4	5	7	225
		2	8.0	0.4	4	4	185
		3	8.0	0.3	5	6	215
3	A:sl	1	7.8	0.3	6	13	315
		2	7.9	0.3	7	7	355
		3	7.9	0.3	5	10	290
4	E:l	1	7.4	0.6	5	13	445
		2	7.3	0.6	5	13	380
		3	7.0	0.4	4	21	440
5	E:l	1	7.0	0.3	6	10	270
		2	6.9	0.3	6	20	270
		3	7.0	0.3	5	8	310
6	E:cl	1	7.3	0.4	9	21	365
		2	7.5	0.6	13	23	490
		3	7.5	0.4	10	33	530
7	Br:vl	1	7.8	0.4	6	17	260
		2	7.7	0.4	6	14	255
		3	7.8	0.3	5	18	270
8	Br:fl	1	7.1	0.6	6	8	325
		2	7.5	0.4	5	3	230
		3	7.8	0.4	5	6	200
9	Br:vl	1	7.8	0.4	11	38	485
		2	7.8	0.3	9	42	530
		3	7.7	0.3	17	56	650
10	E:l	1	7.0	0.2	4	9	475
		2	6.8	0.2	3	11	385
		3	7.0	0.3	4	12	325

.... Continued

Table 1.3.2. (Continued)

Site	Soil Type	Rep.	pH	Salinity mmhos/cm	NO_3^--N	P	K	S
					-------lbs/acre---------			
			Samples Taken August/75 (Cut 2)					
1		1	7.6	0.3	11	20	200	11
		2	7.6	0.3	12	17	170	6
		3	7.6	0.3	9	24	170	4
2		1	7.6	0.4	15	20	255	8
		2	7.6	0.3	12	20	200	4
		3	7.5	0.3	21	26	200	5
3		1	7.5	0.3	8	12	260	5
		2	7.6	0.3	7	15	310	6
		3	7.6	0.3	7	10	275	6
4		1	7.3	0.3	11	24	345	11
		2	7.3	0.4	10	21	375	11
		3	7.3	0.4	12	21	425	11
5		1	7.0	0.3	9	12	235	10
		2	7.0	0.3	12	21	265	7
		3	6.9	0.3	10	13	265	10
6		1	6.4	0.4	9	21	350	11
		2	6.4	0.4	7	25	370	17
		3	7.3	0.4	7	25	345	9
7		1	7.5	0.3	13	18	270	8
		2	7.5	0.3	11	17	270	8
		3	7.5	0.3	11	18	240	7
8		1	7.2	0.7	10	10	300	24+
		2	6.9	1.2	11	12	240	24+
		3	7.6	0.4	10	7	210	21
10		1	7.1	0.2	8	14	375	5
		2	7.2	0.3	7	16	475	4
		3	6.9	0.2	11	10	360	4

Table 1.3.3. Yield data and plant analyses from alfalfa survey sites.

Site	Rep.	Yield D.M. lbs/acre	P %	Mn -----ppm	Zn ------
			June/75 (Cut 1)		
1	1	1560	.35	55	45
	2	1794	.36	51	42
	3	2268	.40	53	38
2	1	2158	.35	36	38
	2	2545	.38	38	42
	3	1958	.35	46	37
3	1	6726	.35	38	32
	2	4945	.35	38	41
	3	5907	.34	39	33
4	1	3551	.34	66	39
	2	3473	.38	66	40
	3	3190	.40	72	49
5	1	3903	.36	120	40
	2	4712	.36	128	43
	3	3153	.39	99	41
6	1	4072	.39	74	37
	2	4167	.41	89	40
	3	4520	.42	84	36
7	1	2812	.44	75	31
	2	1979	.44	75	37
	3	2243	.47	68	32
8	1	3806	.38	64	39
	2	3145	.34	73	35
	3	3709	.36	60	31
9	1	4793	.36	38	38
	2	5909	.34	36	39
	3	6349	.34	36	30
10	1	4819	.37	60	39
	2	4102	.36	73	35
	3	4250	.34	72	37

.... Continued

Table 1.3.3. (Continued)

Site	Rep.	Yield D.M. lbs/acre	P %	Mn ppm	Zn ppm
			August/75 (Cut 2)		
1	1	1614	.35	35	39
	2	1908	.37	30	39
	3	2302	.41	29	42
2	1	2590	.44	24	41
	2	2680	.43	24	42
	3	2354	.42	24	42
3	1	4253	.36	26	43
	2	3842	.33	33	41
	3	4723	.35	26	43
4	1	1456	.36	62	36
	2	1866	.34	65	38
	3	2319	.37	62	41
5	1	3507	.35	91	41
	2	3782	.36	99	45
	3	3350	.34	89	34
6	1	3057	.35	68	33
	2	3087	.35	72	33
	3	3523	.32	76	31
7	1	3276	.37	59	38
	2	2475	.38	63	45
	3	3572	.39	63	36
8	1	2208	.27	61	38
	2	2518	.28	61	35
	3	1757	.21	51	17
10	1	2864	.36	90	50
	2	1372	.36	74	40
	3	2686	.34	85	42

Table 1.3.4. Diagnostic criteria for alfalfa plant analysis.

Nutrient	Plant Part	Nutrient Ranges Deficient	 Critical	 Adequate	 High (Excess)	Reference
		---------	---------%	---------	---------	
P	Top 6 inches	<0.20	0.21-0.25	0.26-0.70	0.71-1.0	1
		---------	---------ppm	---------	---------	
Mn	Top 6 inches	<20	20-30	31-100	250	1
Zn	Top 6 inches	<11	11-20	21-70	70-100	1
Fe	Top 6 inches	<30			>400	2

References

1. Walsh, L. M. and Beaton J. D. ed., 1973. Soil Testing and Plant Analysis. Soil Science Soc. Amer. pp. 400 and 407.

2. Mortveldt, J. J., Giordano, P. M. and Lindsay, W. G. ed., 1972. Micronutrients in Agriculture, Soil Sci. Soc. Amer. pg, 337.

Table 1.3.5. Year of stand establishment and degree of nodulation for alfalfa survey sites.

Site	Year Est.	Nodulation[1] Cut 1	Cut 2
1	1969	1	2
2	1969	1	2
3	1970	2	3
4	1974	4-5	3
5	1971	2	2
6	1969	2	2
7	1974	4	4
8	1972	3	4
9	1969	1	-
10	1969	0	1

[1] Rating system for nodulation

0 = none

1 = very few nodules

2 = few nodules

3 = several nodules

4 = many nodules

5 = very many nodules

2. CROP UTILIZATION AND FATE OF FERTILIZER NITROGEN IN SOIL

2.1. Response of barley to different sources and times of application of nitrogen.

INTRODUCTION

In the fall of 1973 a research program was initiated by the Department of Soil Science, University of Saskatchewan, with the following objectives:

1.) To investigate under the varying conditions prevalent in Saskatchewan the relative responses of crops to different sources and times of application of fertilizer nitrogen.

2.) To determine whether any differences found between sources and application times could be related to specific soil, crop or climatic conditions.

3.) To evaluate the relative contribution to the crop of urea, ammonium, and nitrate-nitrogen applied in fall and spring and to estimate the fate of any such applied nitrogen not utilized by the crop.

In the initial year of the project six trials were set out. In summary, it was found that there were no large consistent yield differences apparent between either urea and ammonium nitrate or fall and spring application. Some individual differences were noted but these were relatively small.

The project was continued in 1974-75 with a further series of 10 field trials.

EXPERIMENTAL METHODS

In the fall of 1974 ten stubble sites were selected for the establishment of field trials. Two sites were on Dark Brown soils (Elstow and Weyburn), five sites were on Black soils (Canora, Hoey, Naicam, Oxbow and Yorkton), two sites were on Degraded Black soils (Carrot River and

Nipawin) and one site was on a Grey Wooded soil (Waitville). The Weyburn, Oxbow and Waitville sites represent soils developed on similar glacial till parent material and occurring in different soil zones. The Naicam and Yorkton soils were both developed on resorted glacial till; the Canora and Elstow soils were both developed on silty glacial lacustrine deposits while the Hoey, Nipawin and Carrot River soils were respectively developed on modified silty lacustrine, sandy alluvium and calcareous sandy alluvium parent materials. Results of analyses of soil samples taken at the time of plot establishment (fall 1974) are presented in Table 2.1.1. Soils at all sites fell in the very low, low, or medium categories for available soil nitrate-nitrogen to two feet. Most of the soils contained appreciable quantities of nitrate below the two foot depth.

At each site, small plots of the randomized complete block design were established containing seventeen treatments replicated six times. Treatments included (Table 2.1.2), aside from the check, two nitrogen carriers (urea and ammonium nitrate) applied in the fall at two rates (50 and 100 lbs. N/acre), and five rates (25, 50, 75, 100, 150, 300 lbs. N/acre) in the spring. Nitrogen in the fall treatments was broadcast at all sites in late October and early November (Table 2.1.3). At most locations permanent snow did not arrive until early to mid December. Soil moisture conditions in spring were fairly good at most sites with the exception of the Oxbow and particularly the Weyburn site where the profiles were fairly low in moisture beyond the 6 and 12 inch depths respectively. At seeding time the plots were worked, seeded and nitrogen was broadcast after seeding. Bonanza barley was used as a test crop and received 40 lbs P_2O_5/acre seed placed as mono-ammonium phosphate (11-55-0).

Table 2.1.1. Characteristics of soils from sites selected for 1974-75 nitrogen fertilizer studies.[1]

Soil Type/ Texture	Depth (in.)	Nutrient Content (lbs./acre) NO_3-N	P	K	SO_4-S	pH	Cond. mmho/cm	O.M. %	$CaCO_3$ %
Canora: sil	0-6	11	16	435	24+	7.5	0.5	6.0	0.8
Thick Black	6-12	7	3	270	24+	7.8	0.7	2.5	7.2
	12-24	12 L[2]	5	465	44+	8.0	2.2		
	24-36	13	8	600	48+	8.1	3.0		
	36-48	27	8	690	48+	7.9	3.2		
Carrot River:	0-6	11	45	225	15	7.8	0.6	6.4	3.1
lvs	6-12	2	8	105	12+	8.0	0.3	0.6	6.0
Degraded Black	12-24	3 L	10	200	48+	8.0	0.2		
	24-36	7	7	200	48+	7.7	0.4		
	36-48	7	11	200	48+	7.8	0.3		
Elstow: l	0-6	9	32	850+	24+	7.3	0.6	3.4	0.5
Dark Brown	6-12	3	9	300	18+	7.4	0.5	1.9	4.5
	12-24	15 L	9	750	40+	7.9	0.7		
	24-36	7	10	925	48+	8.2	0.8		
	36-48	14	23	1065	48+	7.5	3.2		
Hoey: cl	0-6	12	20	520	20+	6.6	0.4	7.4	0.2
Thick Black	6-12	9	9	280	20+	6.7	0.4	5.3	0.2
	12-24	11 M	13	550	35+	7.3	0.6		
	24-36	9	6	640	27	7.7	0.6		
	36-48	11	6	700	44+	7.8	0.7		
Naicam: cl	0-6	12	30	590	24+	7.3	0.8	7.4	0.6
Thick Black	6-12	10	12	350	24+	7.2	0.6	5.2	1.2
	12-24	12 M	5	700	48+	7.8	1.7		
	24-36	19	3	880	48+	7.9	5.4		
	36-48	18	7	880	48+	7.8	5.4		
Nipawin: l	0-6	5	26	245	8	6.6	0.3	3.1	0.5
Degraded Black	6-12	2	25	255	10	6.7	0.4	1.1	0.2
	12-24	3 VL	33	515	23	7.0	0.5		
	24-36	3	21	405	16	7.5	0.4		
	36-48	2	13	315	8	7.7	0.3		
Oxbow: cl	0-6	11	24	360	11	7.1	0.4	6.4	0.3
Black	6-12	5	15	315	9	7.0	0.3	1.5	0.8
	12-24	19 M	21	520	25	7.5	0.4		
	24-36	35	11	430	29	7.9	0.4		
	36-48	30	12	445	20	7.9	0.4		

Table 2.1.1. (Continued)

Soil Type/ Texture	Depth (in.)	Nutrient Content (lbs./acre) NO_3-N	P	K	SO_4-S	pH	Cond. mmho/cm	O.M. %	$CaCO_3$ %
Waitville: l	0-6	8	30	310	6	7.0	0.3	3.2	0.2
Grey Wooded	6-12	5	15	345	4	6.8	0.2	1.2	0.1
	12-24	9 L	26	705	9	6.9	0.4		
	24-36	10	9	515	8	7.6	0.3		
	36-48	11	3	510	8	7.8	0.3		
Weyburn: cl	0-6	10	37	610	24+	7.3	0.4	3.3	0.5
Dark Brown	6-12	7	8	260	24+	7.5	0.4	1.7	3.8
	12-24	13 L	14	410	48+	7.4	1.3		
	24-36	13	16	520	48+	8.0	1.5		
	36-48	19	10	455	48+	7.9	1.7		
Yorkton: l	0-6	12	20	405	8	7.3	0.3	6.8	0.8
Thick Black	6-12	8	7	235	7	7.2	0.3	4.3	0.5
	12-24	12 M	6	430	12	7.8	0.3		
	24-36	15	5	390	29	8.3	0.3		
	36-48	25	7	450	39	8.2	0.3		

[1] Results are from samples taken in the fall of 1974.

[2] Nutrient availability categories as designated by the Saskatchewan Soil Testing Laboratory.
VL - Very Low, L - Low, M - Medium, H - High, VH - Very High.

Table 2.1.2. Treatments included in the 1974-75 nitrogen fertilizer trials.

Nitrogen Application (lbs/acre)	Nitrogen Sources	Time of Application
0		
25	A.N., U.	S
50	A.N., U.	S, F
75	A.N., U.	S
100	A.N., U.	S, F
150	A.N., U.	S
300	A.N., U.	S

A.N. - Ammonium Nitrate

U. - Urea

S. - Spring

F. - Fall

Table 2.1.3. Dates of fall fertilization, spring seeding and harvest and amounts of seasonal precipitation for the 1974-75 nitrogen fertilizer trials.

Soil Site	Fall Fertilization	Seeding	Harvest	Seasonal Precipation (Inches)
Canora	Nov. 4/74	May 27/75	Aug. 14/75	5.4
Carrot River	Oct. 30/74	May 30/75	Aug. 16/75	8.8
Elstow	Oct. 22/74	May 16/75	Aug. 7/75	6.1
Hoey	Oct. 23/74	May 31/75	Aug. 17/75	
Naicam	Oct. 28/74	June 1/75	Aug. 27/75	5.5
Nipawin	Oct. 29/74	May 29/75	Aug. 16/75	6.3
Oxbow	Nov. 5/74	May 26/75	Aug. 12/75	6.3
Waitville	Oct. 31/74	May 28/75	Aug. 26/75	
Weyburn	Nov. 7/74	May 17/75	Aug. 11/75	7.7
Yorkton	Nov. 1/74	May 28/75	Aug. 15/75	5.7

All plots received a pre plant application of triallate (Avadex-BW) for wild oat control. Post emergent herbicide in the form of Buctril-M, MCPA, 2-4D and TCA were applied as necessary. Weed control at most plots was fairly good. The amount of seasonal rainfall received at many locations was fairly low ranging from 5.5 to 8.8 inches. Yields on a few plots, and in particular at the Oxbow site, were probably limited by available moisture.

At maturity, harvest samples were taken from all plots. These samples were air dried, weighed and threshed. The grain collected was cleaned, weighed and yields were calculated. Both grain and straw samples were retained from all treatments on all sites (replicates bulked) and ground in preparation for protein and nitrogen content analysis.

RESULTS AND DISCUSSION

Response of Barley to Applied Nitrogen

Yield results for the various plots are presented in Tables 2.1.4 to 2.1.13. Good responses to applied nitrogen were obtained on the two Dark Brown soil sites where maximum yields of barley attained from spring applied nitrogen were in excess of 40 bu./acre at the 75 to 100 lbs. N/acre application rate. Both soils were initially low in available NO_3-N (near 30 lbs. N/acre to two feet). On four of the five trials on Black soils, reasonably good increases in yield due to applied nitrogen were realized. The greatest yield and strongest response was obtained on the Hoey soil site where yield doubled from approximately 38 bu/acre in the check to almost 80 bu/acre where 100 lbs. N/acre or more was applied. Similar yields and good responses were obtained on this soil in 1974. Maximum responses in the neighborhood of 20 bu/acre at or near the 75 lbs. N/acre application rate were realized at each of the Canora, Naicam and Yorkton

Table 2.1.4. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for an Elstow: 1 soil. (Zelma; Johns)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
				Fall Applied				
0	26.5	1134	1.13	9.7	0.25	19.7	2.8	22.5
50 U[2]	40.2	2303	0.85	9.7	0.25	29.9	5.8	35.7
50 A	46.0	2503	0.89	10.8	0.28	38.2	7.0	45.2
100 U	47.9	2639	0.87	11.5	0.38	42.3	10.0	52.3
100 A	53.5	3040	0.85	13.9	0.53	57.1	16.1	73.2
				Spring Applied				
0	26.7	1155	1.12	9.4	0.28	19.3	3.2	22.5
25 U	34.5	1528	1.08	11.7	0.30	31.0	4.6	35.6
25 A	35.3	1619	1.05	10.8	0.30	29.3	4.9	34.2
50 U	35.0	1743	0.98	12.3	0.45	33.1	7.8	40.9
50 A	38.5	1946	0.96	12.3	0.50	36.4	9.7	46.1
75 U	40.1	1941	1.00	13.2	0.48	40.7	9.3	50.0
75 A	39.9	2154	0.90	12.6	0.58	38.6	12.5	51.1
100 U	40.4	2132	0.94	13.5	0.55	41.9	11.7	53.6
100 A	43.0	2234	0.96	14.8	0.70	48.9	15.6	64.5
150 U	39.1	2280	0.84	13.5	1.05	40.5	23.9	64.4
150 A	43.2	2349	0.89	15.3	1.23	50.8	28.9	79.7
300 U	40.5	2354	0.83	15.0	1.03	46.7	24.2	70.9
300 A	39.2	2368	0.80	15.9	1.50	47.9	35.5	83.4
L.S.D. (.05)	4.7	254	0.15					

[1] % Protein=% N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.5. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for a Weyburn: cl soil. (Saskatoon East)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
				Fall Applied				
0	22.4	1064	1.02	10.3	0.70	17.7	7.4	25.1
50 U[2]	32.4	1803	0.87	10.3	0.35	25.6	6.3	31.9
50 A	35.9	2176	0.81	10.3	0.53	28.4	11.5	39.9
100 U	36.2	2445	0.72	12.4	0.78	34.5	19.1	53.6
100 A	36.9	3178	0.55	13.2	1.05	37.4	33.4	70.8
				Spring Applied				
0	19.2	828	1.12	9.2	0.70	13.6	5.8	19.4
25 U	20.8	935	1.09	10.3	0.65	16.5	6.1	22.6
25 A	24.0	1124	1.03	10.5	0.60	19.4	6.7	26.1
50 U	31.8	1558	1.08	11.5	0.65	28.1	10.1	38.2
50 A	32.7	1807	0.91	12.0	0.65	30.1	11.7	41.8
75 U	35.2	2104	0.85	11.8	0.73	31.9	15.4	46.9
75 A	36.6	2037	0.86	12.2	0.80	34.3	16.3	50.6
100 U	41.8	2172	0.98	13.2	0.80	42.4	17.4	59.8
100 A	40.5	2223	0.88	13.9	1.00	43.2	22.2	65.4
150 U	37.5	2402	0.76	15.9	1.23	45.8	29.5	75.3
150 A	37.3	2304	0.79	15.5	1.53	44.4	35.3	79.7
300 U	41.5	2808	0.71	15.8	1.48	50.4	41.6	92
300 A	33.3	2354	0.70	16.1	1.45	41.2	34.1	75.3
L.S.D. (.05)	8.1	408	0.20					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.6. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for a Canora sil soil. (Walsh; Yorkton)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
				Fall Applied				
0	28.3	1629	0.84	9.9	0.35	21.5	5.7	27.2
50 U[2]	42.7	3013	0.69	11.7	0.38	38.4	11.4	49.8
50 A	39.7	3237	0.60	10.5	0.48	32.0	15.5	47.5
100 U	50.7	3099	0.79	12.4	0.50	48.3	15.5	63.8
100 A	44.2	3109	0.69	13.0	1.00	44.1	31.1	75.2
				Spring Applied				
0	29.0	1507	0.96	11.5	0.30	25.6	4.5	30.1
25 U	39.8	2134	0.90	11.7	0.43	35.8	9.2	45.0
25 A	40.2	2061	0.94	12.4	0.38	38.3	7.8	46.1
50 U	42.4	2398	0.86	12.6	0.48	41.0	11.5	52.5
50 A	43.7	2481	0.85	12.4	0.55	41.6	13.6	55.2
75 U	48.9	2684	0.88	13.0	0.60	48.8	16.1	64.9
75 A	45.4	2719	0.82	12.3	0.68	42.9	18.5	61.4
100 U	47.0	2779	0.82	14.1	0.63	50.9	17.5	68.4
100 A	44.8	2668	0.81	13.7	0.85	47.1	22.7	69.8
150 U	50.5	2850	0.86	13.9	1.03	53.9	29.4	83.3
150 A	47.7	2776	0.83	14.2	1.05	52.0	29.1	81.1
300 U	36.9	2165	0.82	14.6	1.35	41.4	29.2	70.6
300 A	41.7	2474	0.81	14.4	1.35	46.1	33.4	79.5
L.S.D. (.05)	6.9	386	0.13					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.7. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for a Hoey: cl soil. (Njaa; Hagen)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
Fall Applied								
0	42.2	1967	1.03	10.9	0.33	35.3	6.5	41.8
50 U[2]	52.2	2778	0.91	9.9	0.25	39.7	6.9	46.6
50 A	60.0	3335	0.87	9.2	0.25	42.4	8.3	50.7
100 U	64.8	3395	0.93	10.7	0.28	53.3	9.5	62.8
100 A	74.3	3970	0.91	11.4	0.53	65.1	21.0	86.1
Spring Applied								
0	34.6	1460	1.14	10.3	0.45	27.4	6.6	34.0
25 U	49.4	2127	1.12	11.6	0.35	44.0	7.4	51.4
25 A	44.6	1986	1.09	11.2	0.38	38.4	7.5	45.9
50 U	63.3	2882	1.08	10.5	0.30	51.0	8.6	59.6
50 A	56.1	2501	1.10	11.0	0.35	47.4	8.8	56.2
75 U	74.5	3378	1.08	12.4	0.40	70.9	13.5	84.4
75 A	67.3	3224	1.01	12.1	0.35	62.5	11.3	73.8
100 U	69.3	3565	0.94	12.6	0.43	67.1	15.3	82.4
100 A	75.6	3500	1.05	13.5	0.45	78.4	15.8	94.2
150 U	79.0	4124	0.95	13.7	0.68	83.1	28.0	111.1
150 A	76.8	4157	0.91	14.4	0.60	84.9	24.9	109.8
300 U	70.2	4228	0.81	14.8	1.13	79.8	47.8	127.6
300 A	79.0	4126	0.94	14.4	0.90	87.4	37.1	124.5
L.S.D. (.05)	8.0	523	0.13					

[1] %Protein= % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.8. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for a Naicam: cl soil. (Annaheim)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain	N Uptake Straw	N Uptake Total
						-------lb/ac-------		
			Fall Applied					
0	38.3	1725	1.07	11.0	0.63	32.4	10.9	43.3
50 U[2]	40.4	2262	0.87	12.4	0.90	38.5	20.4	58.9
50 A	42.0	2467	0.82	12.8	1.05	41.3	25.9	67.2
100 U	44.4	2344	0.91	11.9	0.88	40.6	20.6	61.2
100 A	38.2	2831	0.67	14.4	1.45	42.2	41.0	83.2
			Spring Applied					
0	39.3	1766	1.10	11.4	0.75	34.4	13.2	47.2
25 U	48.1	2145	1.09	11.2	0.60	41.4	12.9	54.3
25 A	50.2	2323	1.05	11.0	0.75	42.4	17.4	59.8
50 U	53.3	2423	1.06	11.7	0.93	47.9	22.5	70.4
50 A	49.7	2439	0.99	12.1	0.93	46.2	22.7	68.9
75 U	54.3	2595	1.01	12.4	0.95	51.7	24.6	76.3
75 A	57.9	2638	1.06	13.2	1.05	58.7	27.7	86.4
100 U	56.0	2834	0.96	11.7	1.20	50.3	34.0	84.3
100 A	54.3	2726	0.98	12.6	1.10	52.5	30.0	82.5
150 U	53.9	2931	0.88	12.8	1.33	53.0	39.0	92.0
150 A	48.6	2918	0.81	14.1	1.53	53.7	44.6	98.3
300 U	47.0	3081	0.74	15.0	1.53	54.1	47.1	101.2
300 A	45.7	3227	0.68	14.2	1.68	49.8	54.2	104.0
L.S.D. (.05)	6.4	385	0.12					

[1] %Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.9. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for an Oxbow: cl soil. (Weinmaster; Rhein)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
				Fall Applied				
0	28.8	1906	0.73	12.6	0.55	27.9	10.5	38.4
50 U[2]	31.8	2676	0.59	13.5	0.80	33.0	21.4	54.4
50 A	31.9	2534	0.61	15.5	0.98	38.0	24.8	62.8
100 U	35.4	2929	0.58	14.9	1.08	40.5	31.6	72.1
100 A	33.9	2725	0.61	13.5	1.20	35.1	32.7	67.8
				Spring Applied				
0	27.5	1688	0.79	13.2	0.70	27.9	11.8	39.7
25 U	31.0	1967	0.77	13.8	0.78	32.9	15.3	48.2
25 A	29.5	2253	0.64	13.8	0.75	31.3	16.9	48.2
50 U	33.3	2561	0.63	15.3	1.13	39.1	28.9	68.0
50 A	29.7	2280	0.64	13.2	0.98	30.1	22.3	52.4
75 U	32.4	2356	0.67	14.6	1.23	36.3	29.0	65.3
75 A	30.2	2536	0.59	15.5	1.03	36.0	26.1	62.1
100 U	27.2	2739	0.49	16.4	1.13	34.3	31.0	65.3
100 A	29.8	2687	0.54	16.8	0.98	38.4	26.3	64.7
150 U	32.1	2715	0.58	15.9	1.35	39.2	36.7	75.9
150 A	31.2	2595	0.58	17.0	1.33	40.7	34.5	75.2
300 U	25.7	2293	0.56	16.9	1.53	33.4	35.1	68.5
300 A	27.3	2728	0.50	16.8	1.73	35.2	47.2	82.4
L.S.D. (.05)	N.S.	440	0.12					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.10. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley for a Yorkton: 1 soil. (Linstrom; Wadena)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain	N Uptake Straw	N Uptake Total
						------lb/ac-------		
				Fall Applied				
0	31.8	1600	0.96	11.2	0.43	27.4	6.9	34.3
50 U[2]	31.4	1903	0.80	12.8	0.68	30.9	12.9	43.8
50 A	36.5	2438	0.72	12.8	0.65	35.9	15.9	51.8
100 U	33.3	2675	0.60	13.2	0.53	33.8	14.2	48.0
100 A	33.9	2916	0.57	14.8	0.58	38.5	16.9	55.4
				Spring Applied				
0	27.2	1118	1.29	9.6	0.93	20.1	10.4	30.5
25 U	37.6	1933	0.95	10.1	0.45	29.2	8.7	37.9
25 A	33.7	1673	0.97	11.7	0.40	30.3	6.7	37.0
50 U	35.9	2060	0.86	11.5	0.43	31.7	8.9	40.6
50 A	39.4	2271	0.86	12.1	0.40	36.6	9.1	45.7
75 U	48.5	2588	0.90	12.8	0.53	47.7	13.7	61.4
75 A	44.6	2776	0.78	11.7	0.58	40.1	16.1	56.2
100 U	42.9	2370	0.86	13.7	0.65	45.1	15.4	60.5
100 A	34.1	2591	0.63	13.3	0.80	34.8	20.7	55.5
150 U	40.7	2551	0.77	13.0	0.85	40.6	21.7	61.3
150 A	49.6	2853	0.84	13.7	0.90	52.2	25.7	77.9
300 U	40.1	2723	0.74	14.4	1.13	44.3	30.8	75.1
300 A	47.8	3098	0.76	13.5	1.13	49.6	35.0	84.6
L.S.D. (.05)	7.6	430	0.19					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.11. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley on a Carrot River: lvs soil. (Rediger, Carrot River)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
				Fall Applied				
0	34.8	1881	0.92	10.5	0.53	28.1	10.0	38.1
50 U[2]	44.3	2575	0.84	9.6	0.40	32.7	10.3	43.0
50 A	45.5	2838	0.78	9.6	0.43	33.5	12.2	45.7
100 U	54.2	3393	0.78	9.7	0.38	40.4	12.9	53.3
100 A	57.5	3805	0.73	9.4	0.40	41.5	15.2	56.7
				Spring Applied				
0	34.0	1622	1.03	11.2	0.45	29.2	7.3	36.5
25 U	36.0	1793	0.98	9.6	0.55	26.5	9.9	36.4
25 A	40.8	2008	0.99	9.0	0.45	28.2	9.0	37.2
50 U	45.5	2382	0.94	9.4	0.55	32.8	13.1	45.9
50 A	48.2	2697	0.88	8.7	0.43	32.2	11.6	43.8
75 U	46.6	2933	0.79	9.0	0.50	32.2	14.7	46.9
75 A	57.9	3368	0.84	9.9	0.58	44.0	19.5	58.7
100 U	52.1	3398	0.78	9.7	0.50	38.8	17.0	55.8
100 A	57.2	3538	0.78	9.6	0.55	42.2	19.5	61.7
150 U	58.7	3712	0.78	9.2	0.58	41.5	21.5	63.0
150 A	67.2	4326	0.76	11.2	0.80	39.1	34.6	73.7
300 U	52.0	3422	0.73	11.5	1.30	45.9	44.5	90.4
300 A	69.3	5241	0.64	11.7	1.23	62.3	64.5	126.8
L.S.D. (.05)	6.5	551	0.15					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.12. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley on a Nipawin: 1 soil. (Pocock Farm, Nipawin)

Nitrogen Applied (lb/acre)	Yield Grain bu/ac	Yield Straw lb/ac	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/acre)	N Uptake Straw (lb/acre)	N Uptake Total (lb/acre)
				Fall Applied				
0	24.3	1218	0.96	9.6	0.65	17.9	7.9	25.8
50 U[2]	28.9	1487	0.94	9.0	0.50	20.0	7.4	27.4
50 A	33.3	1925	0.85	8.8	0.48	22.5	9.2	31.7
100 U	41.1	2453	0.81	9.7	0.48	30.6	11.8	42.4
100 A	47.2	3264	0.71	11.2	0.83	40.6	27.1	67.7
				Spring Applied				
0	22.7	943	1.16	9.2	0.63	16.0	5.9	21.9
25 U	33.2	1505	1.06	9.9	0.43	25.2	6.5	31.7
25 A	31.0	1479	1.03	9.4	0.53	22.4	7.8	30.2
50 U	41.5	2041	0.99	9.9	0.53	31.6	10.8	42.4
50 A	38.9	2137	0.90	9.4	0.53	28.1	11.3	39.4
75 U	48.9	2434	0.96	9.9	0.50	37.2	12.2	49.4
75 A	48.5	2491	0.95	9.2	0.55	34.3	13.7	48.0
100 U	52.3	2858	0.88	10.9	0.65	43.8	18.6	62.4
100 A	53.9	3018	0.85	12.3	0.68	50.9	20.5	71.4
150 U	59.2	3515	0.82	12.3	0.70	55.9	24.6	80.5
150 A	60.2	3668	0.81	13.1	0.88	60.6	32.3	92.9
300 U	63.3	3465	0.92	13.5	1.00	65.6	34.7	100.3
300 A	58.7	4007	0.71	13.7	1.13	61.8	45.3	107.1
L.S.D. (.05)	8.1	430	0.18					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea.
A = N source was ammonium nitrate.

Table 2.1.13. The effect of spring and fall applications of urea and ammonium nitrate on the yield and nitrogen uptake of Bonanza barley on a Waitville: 1 soil. (Minky Farm, Kelvington)

Nitrogen Applied (lb/acre)	Yield Grain (bu/ac)	Yield Straw (lb/ac)	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	N Uptake Grain (lb/ac)	N Uptake Straw (lb/ac)	N Uptake Total (lb/ac)
				Fall Applied				
0	32.9	1575	1.02	9.2	0.33	23.2	5.2	28.4
50 U[2]	47.2	2549	0.91	8.9	0.38	32.3	9.7	42.0
50 A	54.3	3051	0.86	9.1	0.48	37.9	14.6	52.5
100 U	64.8	3271	0.97	9.5	0.55	47.3	18.0	65.3
100 A	78.1	3464	1.09	12.4	0.63	74.4	21.8	96.2
				Spring Applied				
0	32.2	1447	1.07	8.2	0.33	20.3	4.8	25.1
25 U	43.5	1856	1.18	8.2	0.33	27.4	6.1	33.5
25 A	49.1	2197	1.08	9.6	0.35	36.2	7.7	43.9
50 U	54.3	2282	1.15	9.6	0.35	40.0	8.0	48.0
50 A	56.8	2435	1.14	10.5	0.35	45.8	8.5	54.3
75 U	70.2	2950	1.16	10.9	0.43	58.8	12.7	71.5
75 A	63.8	2736	1.12	10.9	0.40	53.4	10.9	64.3
100 U	73.0	2919	1.20	11.9	0.48	66.7	14.0	80.7
100 A	76.9	3233	1.15	12.3	0.53	72.6	17.1	89.7
150 U	74.6	3265	1.10	13.9	0.65	79.6	21.2	100.8
150 A	75.5	3301	1.10	14.2	0.68	82.3	22.4	104.7
300 U	69.9	3384	1.05	13.5	0.95	72.5	32.1	104.6
300 A	77.2	3415	1.09	14.3	1.05	84.8	35.9	120.7
L.S.D. (.05)	8.1	431	0.16					

[1] % Protein = % N X 6.25 on a 13.5% moisture basis.

[2] U = N source was urea (46-0-0).

A = N source was ammonium nitrate (34-0-0).

soil sites. Overall yields at the Naicam site were approximately 10 bu/acre greater than corresponding treatments on the remaining two sites. All three sites contained similar amounts of NO_3-N (30 lbs. N/acre to two feet and 70 lbs. N/acre to four feet) and received similar low amount of seasonal rainfall (5.5 inches). The fifth Black soil site, the Oxbow plot, gave barley yields of around 30 bu/acre in all treatments. The lack of response on this site was apparently due to a lack of moisture. The crop, which initially germinated uniformly and heavily, seemed to quickly run out of available soil moisture (this soil was dry below the first foot at seeding) and subsequent seasonal rainfall was insufficient to meet crop demands. All three of the northern Degraded Black and Grey Wooded soil plots showed good response to applied nitrogen. Maximum yields on the Carrot River, Nipawin and Waitville soils were respectively around 70, 60 and 75 bu/acre and these yields were attained at application rates of 100 lbs. N/acre or greater.

Yield reductions which appeared to occur at high nitrogen application rates on many of the sites may be a reflection of the significant delay in maturity which was visually present at most locations. On some plots the 300 lbs. N/acre application rate, particularly as urea, visually appeared to result in spotty, irregular germination patterns.

Urea vs. Ammonium Nitrate

Except for one site there is very little indication in the data of consistent differences between yields from the two carriers. Data from the plot on the Carrot River soil indicates that yields from spring applied ammonium nitrate were consistantly and significantly greater than those from urea with the difference ranging from 3 to 17 bu/acre at the various application rates. There are three factors to consider on this soil which could individually or collectively contribute to the relative inefficiency of urea. The Carrot River soil is coarse textured, has a high surface pH (7.8+) and is calcareous to the surface. All three of these properties could and possibly did promote volatile losses of NH_3 gas from urea. Results from the only other coarse textured soil (Nipawin) show no carrier difference, so probably texture alone has little influence on reduced efficiency of urea. The Nipawin soil, however, had an acidic surface pH and was essentially free of carbonates. Unfortunately there have been no other trials in this project on soils with as high a surface pH or which were as strongly calcareous to the surface as the Carrot River.

Fall vs. Spring Application

Results with regard to the comparison of yields from fall and spring nitrogen fertilization are somewhat variable in the 1974-75 data as they were in the previous year. At one location, one of the Dark Brown soil sites (Elstow), the fall applied nitrogen resulted in significantly higher yields than corresponding spring applied nitrogen (5 to 10 bu/acre greater). Yields here were also significantly greater from fall applied ammonium nitrate than from fall applied urea. At three other sites (Naicam, Yorkton and Nipawin soils) yields from all of the spring applied treatments were greater than those from the corresponding fall applied treatments. Such differences were highly significant at the Naicum site. On both the Hoey and Waitville sites, yields from fall applied ammonium nitrate were similar to those from the spring applied treatments; however, fall applied urea treatments were significantly lower. At the four remaining sites (Canora, Carrot River, Weyburn and Yorkton) no large or consistant differences were apparent.

Data is presented in Table 2.1.14 which summarizes the percent recovery

Table 2.1.14. Percent recovery of spring and fall applied nitrogen from trails in 1974-75.

% Recovery (in above ground plant material)

Soil	Elstow :l	Weyburn :cl	Canora :sil	Hoey :cl	Naicam :cl	Oxbow :cl	Yorkton :l	Carrot River :lvs	Nipawin :l	Waitville :l	Average
50-AN-F[2]	45	30	41	18	48	49	35	15	12	48	34
-S	47	45	50	45	43	25	30	15	35	58	39
50-U-F	26	14	45	10	31	32	19	10	3	27	22
-S	37	38	45	52	46	57	20	19	41	46	40
100-AN-F	51	46	48	44	40	29	21	19	42	68	41
-S	42	46	38	60	35	25	25	25	50	65	41
100-U-F	30	29	37	21	18	34	14	15	17	37	25
-S	31	40	38	48	37	26	30	19	41	56	37

[1] $$\% \text{ Recovery} = \frac{\text{Total N uptake in treatment} - \text{Total N uptake in check}}{\text{Rate of N Applied}} \times 100$$

[2] AN = Ammonium nitrate
U = Urea
F = Fall
S = Spring

of applied nitrogen from the 1974-75 trails based solely on total nitrogen uptake values. These results further emphasize the relatively poorer performance of fall applied urea as opposed to any of the other nitrogen treatments.

Fall and Spring Soil Nitrate Contents

An interesting side-light in this project arises from data from soil samples taken in the fall and again in the spring. All plot sites were sampled at the time of establishment and again at seeding time and results of analyses of these soils for NO_3-N content is presented in Table 2.1.15. It is clearly apparent that the NO_3-N content of these soils for the most part rises between the two sampling times, and in some cases this rise was very large. Data such as this would indicate that some adjustments should be made in soil test recommendation procedures for fall to spring samples.

SUMMARY AND CONCLUSIONS

Results from trials conducted during two years have found no major yield difference from spring applied urea and ammonium nitrate on most soil types. On one soil, a Carrot River, which is coarse textured, has a high surface pH and is strongly calcareous to the surface, yields from spring applied ammonium nitrate were significantly larger than those from urea.

Although differences between spring and fall application have been small in most cases and variable, average yield results favour spring application on Black, Grey-Black and Grey-Wooded Soils with yields from fall applied urea and ammonium nitrate averaging 4 to 7 and 3 to 4 bu/acre respectively less than corresponding spring applied nitrogen.

Differences were found between the fall and spring NO_3-N content of most soils encountered during the two years of the project.

Table 2.1.15. Nitrate-nitrogen content of soil from fall and spring sampling of 1974-75 plot site areas.

Depth (Inches	NO_3-N Content (lbs/acre)									
	Canora		Carrot River		Elstow		Hoey		Naicam	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
0-6	11	21	11	12	9	10	12	13	12	18
6-12	7	18	2	5	3	8	9	13	10	17
12-24	12	19	3	8	15	12	11	13	12	15
Total to 2 feet.	30	58	16	25	27	30	32	39	34	50
24-36	13	21	7	5	7	12	9	13	19	14
36-48	27	23	7	7	14	16	11	17	18	15
Total to 4 feet.	70	102	30	37	48	58	52	69	71	79
	Nipawin		Oxbow		Waitville		Weyburn		Yorkton	
	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
0-6	5	5	11	37	8	13	10	10	12	18
6-12	2	3	5	15	5	10	7	5	8	14
12-24	3	8	19	30	9	15	13	10	12	23
Total to 2 feet.	10	16	35	82	22	38	30	25	32	55
24-36	3	8	35	44	10	8	13	17	15	45
36-48	2	9	30	39	11	6	19	17	25	37
Total to 4 feet.	15	33	100	165	43	52	62	59	72	137

2.2. Residual nitrogen at the end of the growing season for the nitrogen experiments.

To determine the possibility of residual response from various rates, sources and times of nitrogen applications, soil samples were taken after harvest. The same consisted of two soil cores of two inch diameter being removed from each of replicate one, three and five from selected treatments. Samples were taken from the zero to six, six to twelve, twelve to twenty-four, twenty-four to thirty-six and thirty-six to forty-eight inch depths. For each individaul treamtnet the soil for each depth from the eight soil cores was composited. Samples were dried immediately and analysed for nitrate nitrogen content.

The data is presented in Table 2.2.1. At the 100 lb/N acre rate small quantities of residual nitrogen were measured in most instances. Exceptions to this were fall applied urea or ammonium nitrate for both the Hoey and Carrot River soils. In general, the residual nitrogen measured from the 100 lb N/acre rate was larger for spring applications than for fall applications and more residual nitrogen was usually measured when ammonium nitrate was used than when urea was the nitrogen source.

At the 300 lb N/acre rate spring applied residual nitrogen was measured in all cases except for the Carrot River soil where the presence of significant quantities of residual nitrogen is doubtful. Most of the residual nitrogen was present in the top foot of the soil profile. There was no consistent evidence of leaching below the four foot depth at any of the locations. Even at the Carrot River location where very little residual nitrogen was present for the 300 lb N/acre rate there is no evidence of leaching, unless the assumption is made that most of the nitrogen leached through the soil profile. A considerable quantity

Table 2.2.1. Residual nitrate nitrogen contents for nitrogen experiments.

Soil	Depth	Fall Applied N (lbs/acre)			Spring Applied N (lbs/acre)				
		0	100 U	100 AN	0	100 U	100 AN	300 U	300 AN
Elstow:l	0-6	5	8	11	11	44	28	82	130
	6-12	2	3	7	2	13	12	26	114
	12-24	4	4	6	4	8	6	10	12
	24-36	4	4	12	8	10	6	8	10
	36-48	10	18	12	12	24	16	14	16
Weyburn:cl	0-6	3	9	10	3	7	10	41	67
	6-12	3	2	4	1	1	2	40	69
	12-24	4	6	8	2	2	4	14	28
	24-36	10	8	6	4	2	6	6	12
	36-48	10	16	10	4	6	6	6	10
Canora:sil	0-6	7	17	21	4	13	21	126	155
	6-12	2	3	11	4	4	5	6	15
	12-24	6	6	10	6	4	8	6	14
	24-36	16	18	16	14	12	18	14	18
	36-48	32	28	23	24	20	28	24	30
Hoey:cl	0-6	3	2	3	2	4	8	148	81
	6-12	2	1	1	1	1	1	6	5
	12-24	4	2	2	2	2	2	6	4
	24-36	4	4	2	4	2	4	4	4
	36-48	6	4	4	4	10	12	12	14
Naicam:cl	0-6	11	9	18	10	9	11	82	140
	6-12	6	5	7	3	4	4	29	59
	12-24	14	8	10	4	8	8	16	18
	24-36	14	16	14	12	20	22	28	20
	36-48	8	14	12	12	16	14	20	20
Oxbow:cl	0-6	11	24	30	18	24	96	165	175
	6-12	3	6	8	3	4	7	15	13
	12-24	10	8	8	6	18	14	48	18
	24-36	24	28	14	28	20	72	16	32
	36-48		30	20	34	22	56	42	38
Yorkton:l	0-6	11	21	17	10	27	25	138	175
	6-12	4	7	15	4	19	19	77	118
	12-24	8	22	10	6	12	14	18	14
	24-36	24	16	20	6	20	20	14	18
	36-48	32	20	44	6	24	34	36	8

Table 2.2.1. (Continued)

Soil	Depth	Fall Applied N (lbs/acre) 0	100 U	100 AN	Spring Applied N (lbs/acre) 0	100 U	100 AN	300 U	300 AN
Carrot River :lvs	0-6	9	11	9	7	10	9	13	12
	6-12	2	3	3	2	1	2	6	2
	12-24	8	8	4	4	4	10	4	4
	24-36	4	4	2	2	4	2	6	4
	36-48	6	4	4	2	4	12	6	6
Nipawin:1	0-6	3	4	6	4	12	17	31	48
	6-12	1	1	12	3	3	6	21	58
	12-24	2	2	16	4	4	4	16	16
	24-36	2	6	4	4	4	6	6	6
	36-48	2	4	8	6	4	6	4	6
Waitville:1	0-6	4	4	21	5	15	6	129	126
	6-12	2	5	11	4	2	2	5	7
	12-24	4	4	6	6	4	4	6	4
	24-36	4	4	6	4	4	4	4	4
	36-48	6	4	4	4	4	4	6	6

of data on similar textured soils in the irrigation area would suggest that such intense leaching would not be expected.

The fall measurements of soil nitrogen is combined with plant recovery of nitrogen to provide an estimate of total recovery (Table 2.2.2). This combined data shows that approximately one third of fall applied urea, one half of fall applied ammonium nitrate or spring applied urea, and three quarters of the spring applied ammonium nitrate could be accounted for in the above ground plant portions and in residual nitrate nitrogen in the soil.

In general, based on the post harvest samples it can be concluded that small but significant quantities of residual nitrogen would occur in many instances for 100 lb N/acre applications and that losses due to leaching are not likely severe under conditions were a crop has been grown.

Table 2.2.2. Recovery of nitrogen at the 100 lb N/acre application rate.

Soil		Fall Applied Urea	Fall Applied A. N.	Spring Applied Urea	Spring Applied A. N.
		----------% Recovery		----------	
Elstow:l	Plant[1]	30	51	40	46
	Soil[2]	12	23	62	31
	Total	42	74	102	77
Weyburn:cl	Plant	29	46	40	46
	Soil	11	8	4	14
	Total	40	54	44	60
Canora:sil	Plant	37	48	38	38
	Soil	9	18	1	28
	Total	46	66	39	76
Hoey:cl	Plant	21	44	48	60
	Soil	0	0	6	14
	Total	21	44	54	74
Naicam:cl	Plant	18	40	37	35
	Soil	0	8	16	19
	Total	18	48	53	54
Oxbow:cl	Plant	34	29	26	25
	Soil (2A)	14	22	19	90
	Total	48	51	45	115
Yorkton:l	Plant	14	21	30	25
	Soil	7	21	80	80
	Total	21	42	110	105
Carrot River:lvs	Plant	15	19	19	25
	Soil	0	0	6	18
	Total	15	19	25	43
Nipawin:l	Plant	17	42	41	50
	Soil	7	36	6	18
	Total	24	78	47	68
Waitville:l	Plant	37	68	56	65
	Soil	1	28	6	0
	Total	38	96	62	65
Average Total Recovery		31	57	58	74

[1] Plant recovery from Table 2.1.14.

[2] Soil recovery is NO_3=N to 4 feet based on treatment minus check.

2.3 Use of microplots to determine the fate of fertilizer N.

INTRODUCTION

The placement of microplots in 20 cm diameter cylinders at each of the 10 sites described in Section 2.1 and 2.2 made it possible to investigate the uptake of the two forms of N in NO_3^-, i.e. NH_4^+ and NO_3^-, and the uptake of urea. They also made it possible to derive a soil N balance sheet to determine the uptake of N in the plant parts, i.e. grain, straw, and crowns in the soil, thus making it possible to calculate losses of N from the soil system.

EXPERIMENTAL TECHNIQUES

Fifty-six kg N/ha were added to each of four cylinders. This N consisted of labelled N containing 5 atom % excess ^{15}N labelled either in the NH_4^+, the NO_3^- or as $(NH_2)_2CO$. The microplots were seeded at the same time as the accompanying large scale field plots. At harvest the plant parts were removed from the cylinders and the soil frozen until analysis. After thawing the soil was sieved and the total soil in the 20 cm by 60 cm cylinder mixed before conducting a Kjeldahl analysis for total N and mass spectrometry for ^{15}N.

RESULTS

Yield of N in the microplots (Table 2.31)

A test of the usefulness of small plot yield data can be conducted by comparing the NO_3^- and NH_4^+ treatments. The N yield should be the same since the treatment is identical and

Table 2.31 Yield of N in 1975 microplots.

Site	Treatment	Yield of N in above ground (kg/ha) Grain	S.E.	Total Above Ground
Weyburn (Saskatoon)	Urea-spring	61.9 a	12.4	74.3
	Urea-fall	47.3 a	7.9	75.6
	NH_4-spring	50.6 a	6.5	70.5
	NH_4-fall	50.8 a	8.6	70.4
	NO_3-spring	49.8 a	4.6	66.7
	NO_3-fall	45.8 a	4.4	68.4
Hoey (St. Louis)	Urea-spring	54.2 abc	6.2	73.6
	Urea-fall	42.5 ab	6.6	64.9
	NH_4-spring	68.2 c	14.9	94.0
	NH_4-fall	35.7 a	3.8	58.5
	NO_3-spring	64.9 bc	7.2	104.7
	NO_3-spring	41.0 a	4.0	58.1
Nipawin	Urea-spring	35.9 bc	4.9	55.1
	Urea-fall	36.0 c	7.7	53.6
	NH_4-spring	27.5 abc	3.9	46.5
	NH_4-fall	18.0 a	4.0	33.9
	NO_3-spring	40.8 c	5.7	61.7
	NO_3-fall	21.0 ab	3.1	38.8
Naicam (Annaheim)	Urea-spring	96.1 a	35.3	126.2
	Urea-fall	52.4 a	5.8	67.2
	NH_4-spring	81.4 a	12.4	103.5
	NH_4-fall	53.7 a	9.8	70.1
	NO_3-spring	68.6 a	4.6	84.9
	NO_3-fall	56.4 a	15.5	75.0
Canora (Yorkton)	Urea-spring	65.4 b	11.2	89.9
	Urea-fall	43.7 a	6.3	63.7
	NH_4-spring	61.4 ab	7.2	87.4
	NH_4-fall	60.8 ab	7.0	78.3
	NO_3-spring	65.4 b	5.7	88.8
	NO_3-fall	47.4 b	5.0	61.5
Yorkton (Wadena)	Urea-spring	49.3 ab	3.1	78.9
	Urea-fall	30.9 a	5.1	53.1
	NH_4-spring	53.2 b	5.4	85.6
	NH_4-fall	37.9 ab	4.0	67.0
	NO_3-spring	57.1 b	13.5	94.6
	NO_3-fall	43.4 ab	5.9	66.8

Table 2.31 Continued.

Site	Treatment	Yield of N in above ground (kg/ha) Grain	S.E.	Total Above Ground
Oxbow (Rhein)	Urea-spring	70.4 a	6.6	102.2
	Urea-fall	71.3 a	14.8	106.9
	NH_4-spring	73.5 a	6.9	103.2
	NH_4-fall	72.3 a	13.1	103.3
	NO_3-spring	65.3 a	7.3	102.1
	NO_3-fall	60.2 a	4.9	91.3
Waitville (Kelvington)	Urea-spring	70.4 b	3.9	87.2
	Urea-fall	39.8 a	2.9	53.2
	NH_4-spring	58.7 b	5.5	76.3
	NH_4-fall	56.9 b	1.3	69.6
	NO_3-spring	62.4 b	6.2	83.8
	NO_3-fall	60.0 b	6.2	73.4
Elstow (Zelma)	Urea-spring	51.2 a	5.9	64.1
	Urea-fall	57.1 a	9.2	70.9
	NH_4-spring	55.5 a	4.1	68.0
	NH_4-fall	61.8 a	2.1	75.8
	NO_3-spring	46.6 a	4.7	61.4
	NO_3-fall	52.4 a	5.4	66.7
Carrot River	Urea-spring	44.0 b	4.6	63.0
	Urea-fall	42.7 ab	5.2	60.9
	NH_4-spring	38.1 ab	4.6	56.3
	NH_4-fall	31.7 ab	4.8	50.6
	NO_3-spring	38.9 ab	4.4	57.3
	NO_3-fall	30.2 a	3.4	45.2

Treatments followed by the same letter are not statistically different at the 0.05 probability level.

the plant cannot differentiate between the labelled and unlabelled fertilizers. The statistics show that the NH_4^+ plus NO_3^-, respectively in spring and fall, show similar results. The plots at Saskatoon showed no differences of yield of N in the grain. The straw could not be statistically analyzed in a similar manner because the Kjeldahl samples had been bulked prior to the determination of N, so no standard errors are given for the straw treatment. The Weyburn-Saskatoon experiment showed no differences in the yield of grain. The Hoey-St. Louis site showed a generally higher amount of N from spring application especially of NO_3-N. The Nipawin site was characterized by having the poorest yield of N from the NO_3-N applied in the fall. On the Naicam site at Annaheim, the very large standard error within the cylinders lead to no statistical differences.

The Canora site at Yorkton showed generally poorer recoveries in the fall than in the spring. Similar data were obtained on the Yorkton soil site at Wadena where urea applied in the spring resulted in a total of 78.9 kg being recovered after fall application of urea. NO_3-N in the spring resulted in a yield of 90.1 kg/ha, whereas fall applied NO_3-N resulted in a yield of 67 kg/ha. The Oxbow soil showed no differences in yield of N. The Waitville soil, although showing a generally lower yield than many of the other sites, showed no differences between treatments except that fall applied urea was much lower than all other treatments. The Elstow site at Zelma showed no differences in treatment, and the Carrot River site showed no differences except that spring applied urea appeared to give a slightly higher amount of N in above ground parts than the other treatments.

Summation (Table 2.32)

Statistical analysis of all ten sites indicated that all sources of N applied in the fall gave a similar N level with an average of 46.7 kg/ha of N in the grain. There was no difference between sources either in the spring or fall, however, spring applied N resulted in an average of 57.5 kg/ha. The microplot yield data therefore clearly indicate a difference in N uptake due to time of application but did not indicate any differences due to type of fertilizer. In comparing these data with the macroplot data cited earlier, it must be remembered that the microplot data were obtained from small sized cylinders at only the 56 kg/ha N application rate, whereas the field scale plots were obtained from experiments with multiple rates. The large scale field plots showed data similar to that obtained with the microplots.

Disposition of N

Percent of N drive from fertilizer (% NDFF)

The labelling of urea and NH_4NO_3 both in the NH_4^+ and NO_3^- ion made it possible to determine the specific fate of the three different forms of N in the various plant parts and in the soil. Calculation of the ^{15}N in the plant parts as a percent of that originally derived from the fertilizer, % NDFF

Table 2.32 Summary of yield of N in above ground plant parts (kg ha^{-1}).

	Grain	Straw	Total
Urea-spring	59.9 c	22.4	82.3
Urea-fall	46.4 a	20.6	67.0
NH_4NO_3-spring	56.4 c	23.5	79.7
NH_4NO_3-fall	46.9 a	19.3	66.2

yields a parameter that is independent of yield and can be calculated for the various plant parts analyzed. Table 2.33 shows the plant distribution as measured with labelled fertilizer for the ten 1975 field plots. The % NDFF for straw in some cases was slightly different from the grain, but in general the two sets of measurements showed similar results. There was a great difference in the % of N that the plant derived from the fertilizer ranging from a low of 3% for the NO_3 applied in fall on the Nipawin site to a high of 28% for the urea applied in spring on the same site. This means that from 62-97% of the N in the plant parts came from the soil with the remainder coming from the fertilizer. This indicates the overall importance of soil nitrate and organic matter in the nutrition of plants when 56 kg/ha of N were applied.

Distribution of fertilizer N in plant parts

Table 2.33 also gives the detailed analysis for the disposition or distribution of labelled N for each of the N sources in the fall and spring application. Urea applied in spring at the Weyburn-Saskatoon site was distributed 20.45% in the grain, 11.37% in straw and 5.18% in the crown for a plant total of 37%. The roots were included within the soil and are not shown for the above ground plant total. Fall application of urea only resulted in 7.8% of the urea N being found in the grain, 6% in the straw and slightly over 3% in the crowns for a plant total of 17.3%. Nitrate N applied in the spring resulted in a recovery of 27% in the

Table 2.33

Plant nitrogen distribution as measured with labelled fertilizer (1975 field plots)

Site	Treatment	Grain % NDFF	Straw % NDFF	Disposition of labelled N (% of added)			
				Grain	Straw	Crowns	Plant total
Weyburn (Saskatoon)	Urea-spring	22.00	30.76	20.45	11.37	5.18	37.0
	Urea-fall	10.33	12.36	7.79	6.24	3.34	17.3
	NH_4-spring	8.79	11.99	15.70	8.53	4.26	28.4
	NH_4-fall	7.03	10.14	12.64	7.11	4.48	24.2
	NO_3-spring	15.59	20.30	27.28	12.22	6.51	46.0
	NO_3-fall	11.55	6.01	19.26	4.85	2.92	27.0
Hoey (St. Louis)	Urea-spring	21.83	25.23	21.23	8.73	4.65	34.6
	Urea-fall	12.45	14.43	9.43	5.78	2.84	18.1
	NH_4-spring	8.64	11.31	21.50	10.42	4.32	36.3
	NH_4-fall	5.84	6.50	7.83	5.28	2.28	15.3
	NO_3-spring	9.33	9.83	21.13	13.94	6.17	41.2
	NO_3-fall	11.13	9.87	16.09	6.03	2.87	24.9
Nipawin	Urea-spring	28.10	27.97	17.03	9.72	4.73	31.5
	Urea-fall	20.39	21.54	15.89	5.50	2.47	23.8
	NH_4-spring	9.23	12.95	9.09	8.51	4.62	22.2
	NH_4-fall	4.64	4.98	5.91	3.91	2.63	12.5
	NO_3-spring	14.33	16.29	20.64	12.14	4.69	37.4
	NO_3-fall	3.14	2.95	2.44	1.87	0.70	5.0
Naicam (Annaheim)	Urea-spring	12.11	11.93	16.19	6.42	4.29	26.9
	Urea-fall	11.01	12.97	10.26	3.44	2.78	16.5
	NH_4-spring	5.51	5.51	15.64	4.35	3.64	23.6
	NH_4-fall	5.77	6.54	11.37	3.84	3.57	18.8
	NO_3-spring	17.01	20.86	41.34	12.12	10.14	63.6
	NO_3-fall	5.97	6.78	12.53	4.51	3.62	20.7

Table 2.33 Continued.

Site	Treatment	Grain % NDFF	Straw % NDFF	Disposition of labelled N (% of added)			
				Grain	Straw	Crowns	Plant total
Canora (Yorkton)	Urea-spring	24.76	20.00	28.20	8.73	3.63	40.5
	Urea-fall	17.24	18.21	13.28	6.51	4.57	24.4
	NH_4-spring	10.24	10.99	21.91	9.01	5.53	36.5
	NH_4-fall	8.37	9.87	17.43	6.18	3.90	27.5
	NO_3-spring	16.44	19.68	37.89	16.45	10.40	64.7
	NO_3-fall	9.52	11.73	16.29	5.03	3.74	25.9
Yorkton (Wadena)	Urea-spring	17.08	19.59	15.05	10.00	1.56	26.6
	Urea-fall	12.38	13.33	6.96	5.10	0.98	13.0
	NH_4-spring	5.88	6.89	11.32	7.70	1.26	20.3
	NH_4-fall	7.08	6.95	9.80	6.22	0.95	16.9
	NO_3-spring	11.93	12.71	22.85	16.63	2.07	41.5
	NO_3-fall	6.40	4.99	7.48	3.79	0.62	8.1
Oxbow (Rhein)	Urea-spring	12.02	17.43	14.62	9.88	2.82	27.3
	Urea-fall	9.23	11.66	10.51	7.42	3.84	21.8
	NH_4-spring	7.87	9.55	19.89	10.13	4.27	34.3
	NH_4-fall	5.48	7.55	12.95	8.35	2.96	24.2
	NO_3-spring	12.20	15.32	27.09	20.09	6.05	53.2
	NO_3-fall	9.44	9.36	20.09	10.38	3.27	33.7
Waitville (Kelvington)	Urea-spring	22.76	25.99	28.41	7.78	4.69	40.8
	Urea-fall	19.17	20.53	13.84	4.91	3.01	21.7
	NH_4-spring	13.37	14.87	27.47	9.32	4.93	41.7
	NH_4-fall	11.07	12.27	22.43	5.58	3.77	31.7
	NO_3-spring	17.25	17.72	37.14	13.52	9.90	60.5
	NO_3-fall	12.63	11.67	26.99	5.58	4.08	36.6

Table 2.33 Continued.

Site	Treatment	Grain % NDFF	Straw % NDFF	Disposition of labelled N (% of added)			
				Grain	Straw	Crowns	Plant total
Elstow (Zelma)	Urea-spring	17.78	22.52	16.14	5.18	2.94	24.2
	Urea-fall	15.00	17.43	17.48	4.32	3.33	25.0
	NH_4-spring	9.63	10.14	18.77	4.54	2.51	25.8
	NH_4-fall	8.63	7.82	16.14	3.93	2.18	22.2
	NO_3-spring	21.48	23.46	35.38	12.37	6.60	54.3
	NO_3-fall	16.55	16.20	30.20	7.93	3.79	41.9
Carrot River	Urea-spring	15.95	18.25	12.56	6.12	1.37	20.0
	Urea-fall	9.37	10.40	14.16	5.96	0.93	21.0
	NH_4-spring	6.28	6.08	8.62	4.54	1.10	14.3
	NH_4-fall	5.83	5.78	6.77	3.83	1.44	12.1
	NO_3-spring	17.70	18.80	21.80	10.90	2.85	35.5
	NO_3-fall	6.07	6.23	8.73	4.09	1.05	13.9

grain, 12% in the straw, 6% in the crowns, for a total recovery of 46%.

The Hoey soils in St. Louis showed responses similar to the Weyburn site in that the NO_3^- applied in the spring gave the highest percent recovery with fall application again resulting in the lowest. In this case the NH_4^+ application gave the lowest recovery. Similar data are shown for many of the other sites with NO_3^- in spring being recovered with the greatest degree of efficiency. Up to 63.6% of the applied fertilizer N was found in the plants in the case of the Naicam, Yorkton and Waitville soils. These data are similar to the 1974 data where six sites indicated that spring applied NO_3 was preferentially utilized for plant growth resulting in reasonably high recoveries. Fall applied NO_3 was especially sensitive to losses from the system. Generally speaking, approximately 20% of the fertilizer N was found in the grain and another 12-15% in the straw and crowns, indicating that if only the grain is removed from the field only a small proportion of the N is removed from the system.

N balance sheets

Table 2.34 gives the detailed analysis for soil N in the various fertilizer treatments on the different soils analyzed. This together with the plant total obtained from Table 2.33 can be used to calculate the recovery of the fertilizer N. Subtraction of the recovery from 100 shows

Table 2.34 Distribution of ^{15}N in soil and plant N (1975 field plots).

Site	Treatment	Disposition of labelled N (% of added)			
		Soil	Plant	Recovery	Loss
Weyburn (Saskatoon)	Urea-spring	39.01	37.00	76.01	23.99
	Urea-fall	37.38	17.37	54.75	45.25
	NH_4-spring	46.26	28.49	74.75	25.25
	NH_4-fall	49.36	24.23	73.59	26.41
	NO_3-spring	24.33	46.01	70.34	29.66
	NO_3-fall	7.72	27.03	34.75	65.25
Hoey (St. Louis)	Urea-spring	36.77	34.61	71.38	28.62
	Urea-fall	38.81	18.05	56.86	43.14
	NH_4-spring	38.67	36.24	74.91	25.09
	NH_4-fall	58.76	15.40	74.16	25.84
	NO_3-spring	26.29	21.24	67.53	32.47
	NO_3-fall	24.61	24.99	49.60	50.40
Nipawin	Urea-spring	47.49	31.48	78.97	21.03
	Urea-fall	39.41	23.81	63.22	36.78
	NH_4-spring	56.46	22.22	78.68	21.32
	NH_4-fall	57.61	12.45	70.06	29.94
	NO_3-spring	34.52	37.47	71.99	38.01
	NO_3-fall	17.34	5.01	22.35	77.65
Naicam (Annaheim)	Urea-spring	21.61	26.90	48.51	51.49
	Urea-fall	29.21	16.48	45.69	54.31
	NH_4-spring	26.82	23.63	50.45	49.55
	NH_4-fall	35.77	18.78	54.55	45.45
	NO_3-spring	18.09	63.60	81.69	18.31
	NO_3-fall	11.46	20.66	32.12	67.88
Canora (Yorkton)	Urea-spring	31.61	40.56	72.11	27.83
	Urea-fall	26.87	24.36	51.23	48.77
	NH_4-spring	30.92	36.45	67.37	32.63
	NH_4-fall	33.51	27.51	61.02	38.98
	NO_3-spring	24.44	64.74	89.18	10.82
	NO_3-fall	16.91	25.96	42.87	57.13
Yorkton (Wadena)	Urea-spring	17.16	26.61	43.77	56.23
	Urea-fall	14.79	13.04	27.83	72.17
	NH_4-spring	17.48	20.31	37.79	62.21
	NH_4-fall	27.31	16.97	44.28	55.72
	NO_3-spring	16.71	41.55	58.26	41.74
	NO_3-fall	3.52	11.89	15.41	84.59

Table 2.34 Continued.

Site	Treatment	Disposition of labelled N (% of added)			
		Soil	Plant	Recovery	Loss
Oxbow (Rhein)	Urea-spring	32.11	27.32	59.43	40.57
	Urea-fall	23.04	21.77	44.81	55.19
	NH_4-spring	37.49	34.29	71.78	28.22
	NH_4-fall	38.75	24.26	63.01	36.99
	NO_3-spring	24.94	53.23	46.77	21.83
	NO_3-fall	9.78	33.74	43.52	56.48
Waitville (Kelvington)	Urea-spring	27.78	40.88	68.66	31.34
	Urea-fall	29.37	21.76	51.13	48.87
	NH_4-spring	36.59	41.72	78.31	21.69
	NH_4-fall	40.45	31.78	72.23	27.77
	NO_3-spring	23.51	60.56	84.07	15.93
	NO_3-fall	17.28	36.65	53.93	46.07
Elstow (Zelma)	Urea-spring	43.69	24.26	67.95	32.05
	Urea-fall	48.53	25.13	73.66	26.34
	NH_4-spring	59.06	25.82	84.88	15.12
	NH_4-fall	49.39	22.25	71.64	28.36
	NO_3-spring	30.32	54.35	84.67	15.33
	NO_3-fall	30.37	41.92	72.29	27.71
Carrot River	Urea-spring	29.94	20.05	49.99	50.01
	Urea-fall	29.79	21.05	50.84	49.16
	NH_4-spring	22.81	14.26	37.07	62.93
	NH_4-fall	37.69	12.04	49.73	50.27
	NO_3-spring	23.76	35.55	59.31	40.69
	NO_3-fall	8.12	13.87	21.99	78.01

the percent loss of the N. This table shows that in the Saskatoon site 46 and 49% respectively of the NH_4^+ added in spring and fall still remained in the soil, whereas 24 to 28% was found in the plant, for a total recovery of approximately 75% and a loss of 25%. Analysis of the soil beneath the 60 cm deep cylinders and data from deeper cylinders (Campbell and Paul, 1977) indicate that a majority of this N has not been leached from the depth of soil analyzed but has been lost via volatilization, denitrification and possibly some loss of above ground vegetation plant parts.

The Hoey-St. Louis soil showed a high recovery of NH_4^+ within the soil especially on fall application and a low percentage of NO_3-N within the soil, with an overall loss ranging from 25 to 50%. The Nipawin site again showed very low NO_3 levels in the soil in fall. This together with low plant uptake of the NO_3-N indicated a recovery of only 22% with a subsequent loss of 78% for the NO_3 added in the fall. Urea added in the fall showed a slightly greater loss than spring applied urea but only accounted fro 36% of the N added.

The data for distribution of N are summarized in Table 2.35 where the mean of the ten microplot sites are shown. Urea applied in fall resulted in 11.6% recovery in the grain, 8.3% in the straw and crowns, and 31.7% in the soil with a loss of 48%. Spring applied urea showed a grain recovery of 19.0%, 12.0% in the straw and 32.7% in the soil for a

Table 2.35 Nitrogen balance sheet (mean of 10 microplot sites).

Treatment	% utilization of applied fertilizer N			
	Grain	Straw + Crowns	Soil	Loss
$(NH_2)_2CO$-fall	11.6	8.3	31.7	48.4
$(NH_2)_2CO$-spring	19.0	12.0	32.7	36.3
NH_4^+-fall	12.3	8.2	42.9	36.6
NH_4^+-spring	17.0	11.4	37.3	34.3
NO_3^--fall	16.0	8.2	14.7	61.1
NO_3^--spring	29.3	20.6	24.7	25.4
NH_4NO_3-fall	14.2	8.2	28.8	48.8
NH_4NO_3-spring	23.2	16.0	31.0	29.8

loss of 36%. Fall applied NH_4^+ showed similar data with lower recoveries in the grain and straw but higher recoveries in the soil with a 34-36% loss figure. These data show a preferential immobilization of NH_4^+ by the soil, especially when it was applied in the fall.

Fall applied NO_3-N was especially susceptible to losses for only 16% was found in the grain, 8% in straw and crowns, 14.7% in the soil for a total of 39% and a loss of 61%. Spring application showed that NO_3-N is preferentially utilized when available for 29.3% of the material was found in the grain, 20.6% in the straw and crowns, and 24.7% was immobilized in the soil with a consequent loss of 25%.

The low plant recovery of fertilizer N in the plants of all treatments with the exception of spring applied NO_3 is a direct result of high losses and a high soils residual ^{15}N content. However, the high concentration of urea and NH_4^+-N remaining in the soil should result in a better residual level of N than when NO_3 is applied. Fall applied NO_3-N showed great losses. These losses are similar to those recorded in 1972, 1973, and 1974, which showed that 20-40% of the N in spring applied N sources could not be accounted for with much higher levels of loss occurring when NO_3 was applied in the fall. Although urea appears to have a slightly higher loss on fall application than spring applied urea or ammonia, this was due to a lower level of this compound remaining in the soil at harvest time. Plant utilization was similar for NH_4^+ and urea.

Table 2.36 rearranges the recovery on a statistical basis. Group I soils showing a low recovery all consisted of fall applied fertilizer. Group II soils included fall applied NO_3 which although subject to high losses was also preferentially utilized by the plant.

Grouping the recovery in the soil shows nearly opposite results to that obtained in the plant with fall applied NO_3 showing very low recovery in a group by itself. Spring applied NO_3 showing a separate individual group at 24.7% and NH_4^+ being very strongly held within the soil system. These data indicate that extensive leaching or denitrification processes account for poor performance when fall N is applied. Fall applied NH_4^+ showed low plant uptake but high soil residual N levels indicating that the two ions in ammonium nitrate behave quite differently under different environmental conditions.

Table 2.36 % recovery of specific N forms in the grain and soil.

Grain			Soil		
Group*		Mean % Recovery	Group*		Mean % Recovery
I	$(NH_2)_2CO$-fall	11.4	I	NO_3-N-fall	14.7
	NH_4-N-fall	12.3	II	NO_3-N-spring	24.7
	NO_3-N-fall	15.1	III	$(NH_2)_2CO$-fall	31.7
II	NO_3-N-fall	15.1		$(NH_2)_2CO$-spring	32.7
	NH_4-N-spring	17.0		NH_4-N-spring	37.3
	$(NH_2)_2CO$-spring	18.6	IV	NH_4-N-spring	37.3
III	NO_3-N-spring	29.3		NH_4-N-fall	42.9

*Each group separated at the 0.01 probability level.

2.4 Comparisons of N recovery on a field scale basis and the N distribution data obtained with ^{15}N.

To obtain a more meaningful expression for the yield of N on the field scale plots, the yield of N in kg/ha in the grain plus straw was plotted as a function of fertilier N form (urea and NO_3-N) and type of application. The computer plots of the yield of N vs. applied N for the first 100 kg of N applied showed some high correlation coefficients with the r^2 being as low as 37% but generally ranging in the 70 to 80% area. Invariably the lowest r^2 denoting the percentage variability accounted for was found for the fall urea treatment. The relatively ineffectiveness of fall applied urea in comparison to the other treatment is evident.

Extrapolation of the regression line to the x-axis gives a measure of the available soil N expressed in terms of the specific applied fertilizer N (Table 2.41). The response of grains as shown by the yield of N was lower for fall applied fertilizers. Thus the x-intercept for fall applied urea was 154 kg N/ha whereas that of NO_3-N was 94 kg N/ha. These data corroborate the ^{15}N data showing the generally high N supplying power of these soils.

The relative rating of fertilizers as judged by the x-intercept can best be determined by rating NO_3-N in spring as 100. This indicated a relative rate of urea in spring as 91% and fall applied NO_3-N and urea as 63 and 39%, respectively (Table 2.41). Another comparison of the data

Table 2.41 Mean "x-intercept" values (kg N/ha).

Treatment	x-intercept values (kg N/ha)	Comparative efficiency (%) of fertilizer treatment
NH_4NO_3-fall	94 $\pm$ 59	63
NH_4NO_3-spring	77 $\pm$ 28	100
$(NH_2)_2CO$-fall	154 $\pm$ 83	39
$(NH_2)_2CO$-spring	84 $\pm$ 54	91

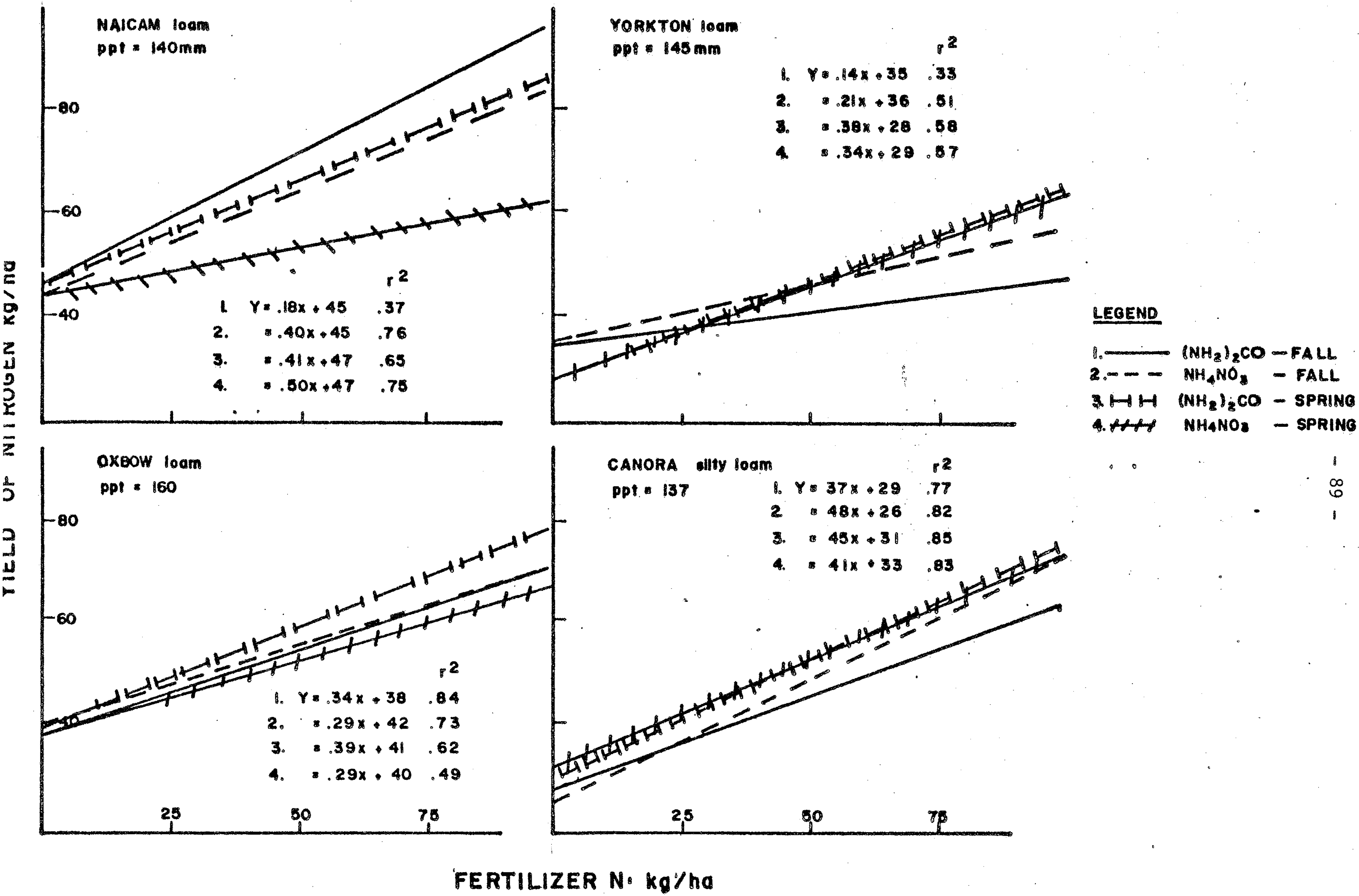

FIGURE 2.41 YIELD OF NITROGEN (GRAIN + STRAW) AS A FUNCTION OF FERTILIZER N FORM ($(NH_2)_2CO$ VS. NH_4NO_3), TIME OF APPLICATION (FALL VS. SPRING), AND RATE.

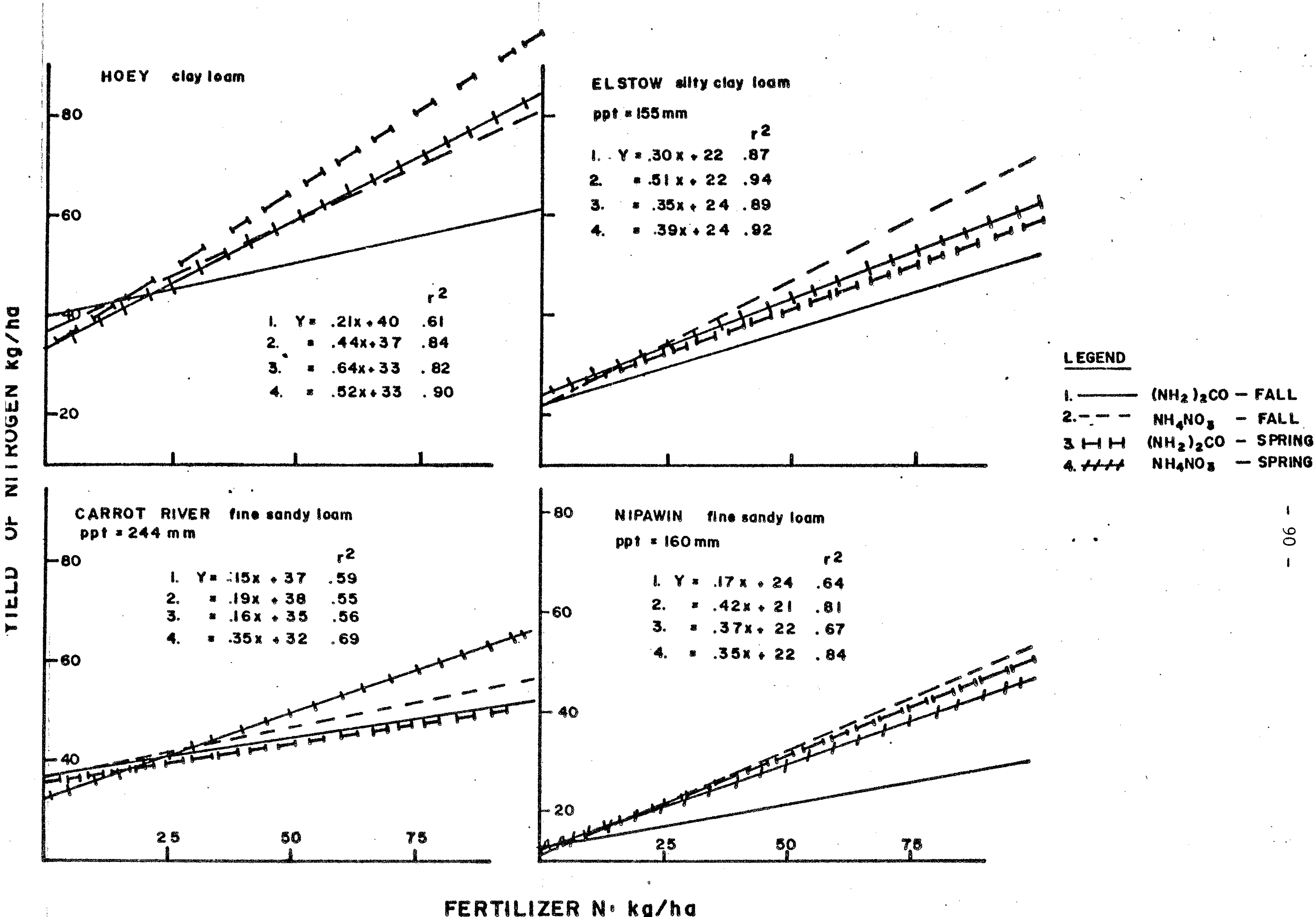

FIGURE 2.41 YIELD OF NITROGEN (GRAIN + STRAW) AS A FUNCTION OF FERTILIZER N FORM ($(NH_2)_2CO$ VS. NH_4NO_3), TIME OF APPLICATION (FALL VS. SPRING), AND RATE.

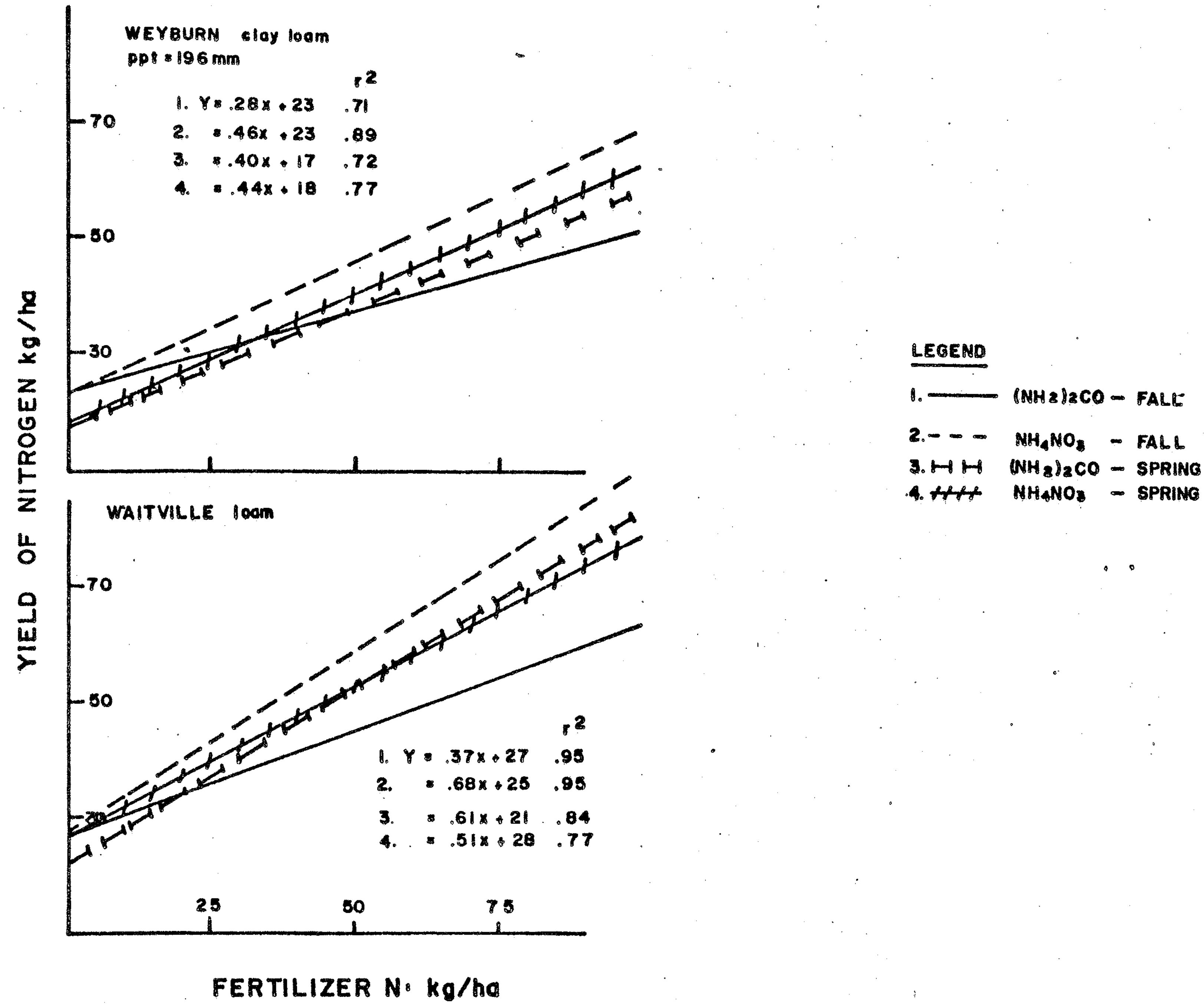

FIGURE 2.41 YIELD OF NITROGEN (GRAIN + STRAW) AS A FUNCTION OF FERTILIZER N FORM ($(NH_2)_2CO$ VS. NH_4NO_3), TIME OF APPLICATION (FALL VS. SPRING), AND RATE.

can be obtained by multiplying the value of % N derived from the fertilizer (% NDFF) in the microplots by the yield of N and dividing by the fertilizer application rate to calculate a percent utilization for both the microplots and the macro field plots. Table 2.42 shows a calculation using ^{15}N data that are averaged for the two ions, NH_4^+ and NO_3^-, to make comparison with the large scale field plots possible. The general plant uptake of fertilizer N was low resulting in a low percentage of N coming from the fertilizer. Results from previous years experiments have shown % NDFF ranging as high as 50% compared to this year's 14 to 19%. The percent utilization of applied fertilizer in the macroplots and field plots was very similar. This is not surprising since the earlier discussion in this paper indicated that the yields within the two types of plots were similar. Calculating the relative efficiency of N on a % utilization basis indicates that NO_3-N in spring has an arbitrarily defined efficiency as 100. In the field scale plots urea in spring was 81%, NO_3-N in fall 72%, and urea in fall 51%. The comparative efficiencies based on isotope derived data are therefore similar to those given by the x-intercept values obtained from Fig.2.41 and shown in Tables 2.37 where relative efficiencies of 100, 91, 63 and 31 were obtained for spring NH_4NO_3 spring urea, fall NH_4NO_3 and fall urea.

GENERAL CONCLUSIONS

1. Fertilizer form (NH_4^+, $(NH_2)_2CO$, or NO_3^-) did not affect the protein content of the grain or N content of the

Table 2.42 Comparison of field plot vs. microplot derived data (mean of ten plots).

Treatment	% NDFF	% utilization of applied fertilizer*		Relative efficiency	
		Microplots	Field plots**	Microplots	Field plots
NH_4NO_3-fall	16.6	14.2	17.2 ± 5.6	61	72
NH_4NO_3-spring	23.7	23.2	23.9 ± 5.8	100	100
$(NH_2)_2CO$-fall	14.0	11.6	12.1 ± 3.1	50	51
$(NH_2)_2CO$-spring	19.4	19.0	19.3 ± 5.5	82	81

*% utilization by grain + straw for the 50 kg N/ha rate of application. The data for NDFF are the mean values for % N in the grain derived from the fertilizer.

**The 'Field Plots' data was obtained using % utilization calculated from N15 data in the microplots and yield of N was determined from regression analysis of the field plot data.

straw.

2. The yield of barley was increased by approximately 14 kg for each kg of N applied per ha when the fertilizer rate was in the region of the soil test recommendation.
3. While the relative performance of $(NH_2)_2CO$ and NH_4NO_3 varied from site to site, yield data did not show any significant difference between the two sources when broadcast and worked into the soil in the spring (6 sites favored NH_4NO_3, 4 $(NH_2)_2CO$ or when NH_4NO_3 was fall applied. However, fall applied $(NH_2)_2CO$ was less effective.
4. The N^{15} derived data indicate the following relative efficiency: NH_4NO_3 spring (100), $(NH_2)_2CO$ spring (81), NH_4NO_3 fall (72), $(NH_2)_2CO$ fall (51). Similar data were obtained by computer calculations of the field scale data and determination of the x-intercept to show soil N expressed in terms of applied N.
5. The fate of fertilizer N in the various plant parts and soil, together with loss estimates, to a large extent explain the comparative efficiency of fall and spring applied N sources.
   a) fall applied $(NH_2)_2CO$ is subject to both volatilization and leaching losses,
   b) leaching and denitrification probably account for the poor performance of fall applied NO_3,
   c) both NH_4^+ and $(NH_2)_2CO$ forms are subject to rapid immobilization. While this process adversely

affects the efficiency in the year of application, this N will be of value to future crops, and

d) the excellent efficiency of spring applied NO_3-N is a reflection of its positional availability, i.e. mobility in the soil.

6. There is little indication to support the suggestion that $(NH_2)_2CO$ performs better in low pH or lime-free soils.
7. The high level of NO_3-N loss in fall application supports the concern about extensive losses of N under summer-fallowing conditions. If rapid leaching or denitrification of fertilizer N occurs in the fall, there is no reason why soil NO_3-N should behave differently.
8. This excellent set of ten field trials in central and northeastern Saskatchewan corroborates earlier data obtained in 1972 and 1974. These data also indicated a poor performance of fall applied fertilizer and slightly better performance for NH_4NO_3 relative to urea.

3. PRODUCTIVITY STUDIES ON SOLONETZIC SOILS, WEYBURN MAP AREA

INTRODUCTION

Concurrent with the soil survey of the Weyburn - Virden map areas the Saskatchewan Institute of Pedology has initiated a study to compare productivity levels among different soil profile types or soil series of selected soil associations. Because of the importance of Dark Brown Solonetzic soils in this area the study concentrated on two associations which are dominantly Solonetzic, the Trossachs and Brooking Associations. Comparisons were made with Chernozemic Dark Brown soils of the Amulet Association. Additional objectives of the study were to obtain basic data relating yield to soil and other environmental properties, and to assess the practicability of lengthening crop rotations on Dark Brown Solonetzic soils.

EXPERIMENTAL METHODS

Five sites approximately 20-25 ha in area were selected (Table 1). At each site two representative transects were chosen and profiles typical of different soil series were selected at random. There were 15 profiles or plots at each site, generally five replicates of the three most commonly occurring series (Figure 3.1). At each plot soils were sampled to 60 cm depth at seeding and available plant nutirents, salinity levels and pH were measured. Access tubes were installed for monitoring soil moisture with the neutron moisture meter at 18-day intervals through the growing season. Crop condition was observed at similar intervals. Precipitation was measured and recorded by the

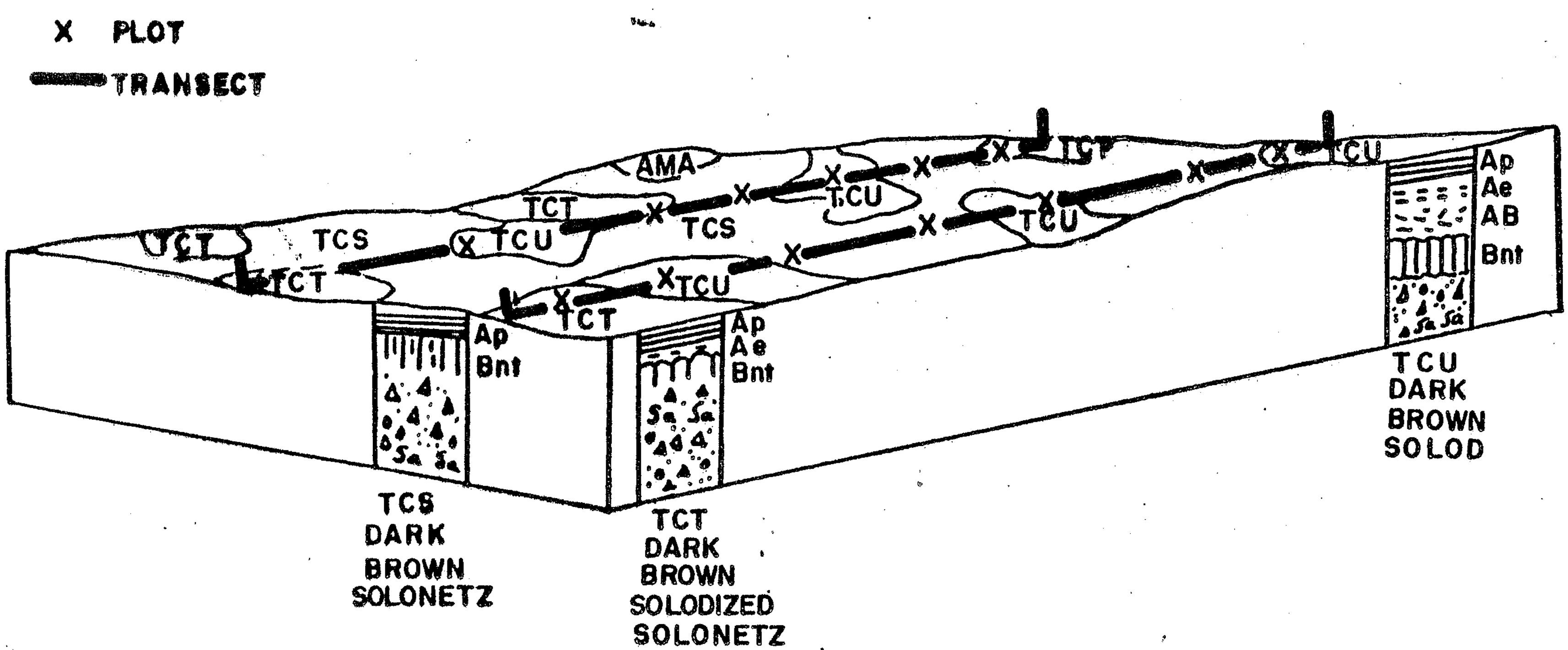

FIG. 3.1 SOIL DISTRIBUTION AND POSITION OF SAMPLE PLOTS AT A TYPICAL SITE WHERE SOLONETZIC SOILS ARE DOMINANT

cooperating farmers. Estimates of total and grain yields were obtained by sampling duplicate square meter areas. After harvest soil pits were dug, soil profiles described and the B and C horizons sampled to 1.2 m depth.

Wheat on summerfallow was grown at all sites with the normal management practised by the farmer cooperators.

The soil profiles or series studied were:

AMA - Orthic Dark Brown, Amulet Association

BKW - Solonetzic Dark Brown, Brooking Association

BKY - Solodic Dark Brown, Brooking Association

TCS - Dark Brown Solonetz, Trossachs Association

TCT - Dark Brown Solodized-Solonetz, Trossachs Association

TCU - Dark Brown Solod, Trossachs Association

The BKW and BKY series are weakly developed solonetzic soils, with profiles that have some characteristics of solonetzic soils such as strong subangular blocky structures and clay and organic matter coatings in their B horizons. However, they lack the degree of B horizon development and salinity characteristics of the more strongly developed solonetzic soils. The TCS, TCT and TCU soils are stongly developed solonetzic soils.

Soil analyses were done by the Saskatchewan Soil Testing Laboratory using their standard methods. Electrical conductivity (EC) measurements were on a 1:1 soils and water suspension and were expressed as millimhos/cm at 25°C. EC and soluble cation measurements of the B horizons used the saturated paste method.

Soluble sodium percentages (SSP) were calculated as water soluble sodium divided by the sum of the soluble cations, with

Table 3.1 Yields and protein levels of each series at each location.

Co-operator and location	Series	Number of Replicates	Total Yield kg/ha	Grain Yield kg/ha	Protein %
Schnell	AMA	4	4901	2650	15.6
Secs. 1 and 2,	BKY	4	4327	2312	13.6
1-12W2	BKW	6	4030	2171	14.2
(278 mm growing	TCU	1		2162	15.2
season ppn)					
Halvorson	BKW	1		2606	13.6
36-1-12We	TCU	5	4060	2343	16.8
(175 mm growing	TCS	5	3489	2278	15.9
season ppn)	TCT	4	2840	1893	16.8
Lievaart	BKY	1	2986	2401	14.0
6-2-10W2	BKW	3		2115	15.8
(180 mm growing	TCU	4	2871	2084	15.8
season ppn)	AMA	3	2544	2002	15.5
	TCS	4	2162	1602	15.1
Memory	BKW	1		3017	14.3
31-1-10W2	BKY	1		2253	17.4
(176 mm growing	TCU	4	3758	2100	17.5
season ppn)	TCS	6	3469	1861	17.1
	TCT	3	2743	1655	17.5
Flaten	TCS	4	1730	1072	18.7
8-8-16W2	TCU	3	1673	1024	18.5
(84 mm growing	TCT	8	1388	832	18.7
season rain)					

concentrations as me/l. Sodium adsorption ratios were calculated as:

$$SAR = \frac{Na^{+}}{\sqrt{Ca^{++} + Mg^{++}/2}}$$

with concentration in me/l. Exchangeable sodium percentage (ESP) was calculated as exchangeable Na^{+}/exchangeable $Ca^{++} + Mg^{++} + K^{+} + Na^{+}$ with concentration in me/100 g soil.

RESULTS AND DISCUSSIONS

Yields at the Flaten site near Weyburn were considerably less than those of the Torquay - Outram area (Table 3.1). The small amount of growing season precipitation at the Flaten site was largely responsible for the reduced yields, although the more strongly solonetzic character of the soils and the general occurrence of subsoil salinity at shallower depths may have contributed as well. At all sites yields were lowest for the most strongly solonetzic soils, the Solodized-Solonetz (TCT) and Solonetz (TCS) series. Protein concentrations almost equal concentrations for some of the higher yielding sites. Nitrate-N levels were generally high at all sites.

Comparisons among series, considering all sites, showed that yields were lowest for the TCT soils, with increases in the sequence TCS, TCU (Dark Brown Solod), to highest and approximately equal yields for the weakly solonetzic BKW and BKY series and the Orthic Dark Brown (AMA) series (Table 3.2). Excluding the drought-affected Flaten site did not change this sequence, but did reduce the range between the highest yielding AMA series at 2372 kg/ha, and the lowest yielding TCT series at 1780 kg/ha mean yield.

The grain/grain + straw ratios were between 0.53 and 0.64.

Table 3.2 Yields, protein levels and soil properties of the series studied.

Series	No. of Reps.	Total Yield kg/ha	Grain Yield kg/ha	Protein %	Grain Yield / Total Yield	NO_3-N 0-60 cm kg/ha	Avail. P 0-15 cm kg/ha
AMA	7	3723	2372	15.7	0.64	86	16
BKY	6	4327	2317	14.3	0.53	105	22
BKW	11	3404	2272	14.6	0.66	100	18
TCU	17	3090	1981	17.0	0.64	110	21
TCS	19	2712	1750	16.6	0.64	111	20
TCT	15	230	1297	18.0	0.56	128	19

Table 3.3 Properties of the series studied.

Series	No. of Reps.	B horizon SSP %	B horizon ESP %	EC C horizon mmhos/cm
AMA	7	28	1.9	2.1
BKY	6	39	3.4	2.9
BKW	11	39	4.7	2.4
TCU	17	50	4.9	3.6
TCS	19	65	11.3	5.9
TCT	17	81	22	8.2

Protein concentrations were highest for the more strongly solonetzic series, the TCS, TCT and TCU soils, probably because of the high values for the strongly solonetzic Flaten site. Available P levels were relatively similar among series, at 16-22 kg/ha available P in the 0-15 cm depth. NO_3-N levels (0-60 cm depth) were lowest for the chernozemic and weakly solonetzic soils, highest for the strongly solonetzic soils.

Soluble sodium percentages (SSP), exchangeable sodium percentage (ESP) and salinity of the subsoils varied regularly with soil series. Lowest salinity, ESP and SSP values were noted for the AMA series, increasing with the degree of solonetzic character, as inferred from soil morphological properties. The data illustrates that the solonetz-like or solonetz-chernozemic intergrade soils, with weakly expressed solonetzic characteristics, are quite similar to chernozemic soils in their chemical composition. The range of values observed, however, indicates that no single criterion will separate chernozemic and solonetzic soils. It appears that the "solonetzic" morphology of the intergrade (BKW and BKY) as well as the solod (TCU) profiles are largely relict, developed prior to deep leaching of sodium.

A significant negative correlation between grain yield and NO_3^--N contents of the 0-60 cm depth was observed (Table 3.4). This was surprising, and is probably related to other properties of the soils. For example, NO_3-N levels were highest in soils where tough, impermeable B horizons and saline subsoils probably reduced yields. This is suggested by negative correlations between yield and SSP, ESP and EC values of the subsoil.

Available P levels were not correlated with yields although considerations within series showed a positive correlation between yield and P level for the BKY and TCU series groups.

Moisture use and extraction with depth will not be discussed here. It was covered briefly in the presentation to the 1976 Soil Fertility Workshop (Anderson and Wilkinson, 1976). The data is stored on computer tape for use in the future.

Table 3.4 Some correlation coefficients, yield versus soil properties.

Soil Property	Correlation with Grain Yield r	R^2
A horizon cm (Ap, Ae + AB)	0.07	0.004
SSP of B	-0.63	0.39
ESP of B	-0.64	0.41
SAR of B	-0.62	0.39
EC, 0-15 cm	-0.36	0.13
EC, 15-30 cm	-0.45	0.19
EC, 30-60 cm	-0.44	0.19
EC, 60-90 cm	-0.52	0.28
EC, 90-120 cm	-0.62	0.38
NO_3-N, 0-60 cm	-0.41	0.16
Avail. P, 0-15 cm	0.28	0.08

Signifiance, 5% level = 0.22, 1% level = 0.29

LITERATURE CITED

Anderson, D. W. and D. B. Wilkinson, 1976. Productivity studies in the Weyburn map area. Proc. of the 1976 Soil Fertility Workshop. Ext. Pub. 244, University of Saskatchewan, Saskatoon.

APPENDICES

Appendix A - Legal water location and soil type of experimental field plots for 1975 irrigation trails.

Farmer Cooperator	Crop Investigated	Legal Location	Soil Type
M. Cameron	Barley Soft Wheat Rapeseed	SW27-29-8-W3	Bradwell: vl
A. Pederson	Barley Soft Wheat Rapeseed	NW21-28-7-W3	Elstow: 1

Appendix B - Legal location and soil type of experimental field plots for 1975 nitrogen trails.

Farmer Cooperator	Crop Investigated	Legal Location	Soil Type
L. Johns	Barley	NW16-33-28-W2	Elstow: 1
A. Knitting	Barley	NE31-38-20-W2	Naicam: cl
V. Lindstrom	Barley	SE4-35-13-W2	Yorkton: 1
Wm. Minky	Barley	SW4-38-10-W2	Waitville: 1
S. Njaa	Barley	SE5-45-25-W2	Hoey: cl
D. Pocock	Barley	NE11-51-14-W2	Nipawin: cl
P. Rediger	Barley	SE11-49-12-W2	Carrot River: lvs
A. Weinmaster	Barley	SW19-27-2-W2	Oxbow: cl
C. Walsh	Barley	NE33-26-4-W2	Canora: sil
------------	Barley	NW34-36-2-W3	Weyburn: cl